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ANNUAL REPORT

OF THE

BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING THE

OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION FOR THE YEAR 1861.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1862.

LETTER

OF THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

COMMUNICATING

The Annual Report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1861.

June 5, 1862.—*Ordered*, That three thousand extra copies be printed for the use of the members of the House of Representatives, and two thousand for the use of the Smithsonian Institution.

Smithsonian Institution,
Washington, June 4, 1862.

Sir: In behalf of the Board of Regents, I have the honor to submit to the House of Representatives of the United States the Annual Report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1861.

I have the honor to be, very respectfully, your obedient servant,

JOSEPH HENRY,
Secretary Smithsonian Institution.

Hon. G. A. Grow,
Speaker of the House of Representatives.

ANNUAL REPORT OF THE BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION UP TO JANUARY, 1862, AND THE PROCEEDINGS OF THE BOARD UP TO MAY, 1862.

To the Senate and House of Representatives:

In obedience to the act of Congress of August 10, 1846, establishing the Smithsonian Institution, the undersigned, in behalf of the Regents, submit to Congress, as a report of the operations, expenditures, and condition of the Institution, the following documents:

1. The Annual Report of the Secretary, giving an account of the operations of the Institution during the year 1861.

2. Report of the Executive Committee, giving a general statement of the proceeds and disposition of the Smithsonian fund, and also an account of the expenditures for the year 1861.

3. Proceedings of the Board of Regents up to May, 1862.

4. Appendix.

Respectfully submitted.

R. B. TANEY, *Chancellor.*
JOSEPH HENRY, *Secretary.*

OFFICERS OF THE SMITHSONIAN INSTITUTION.

ABRAHAM LINCOLN, *Ex officio* Presiding Officer of the Institution.
ROGER B. TANEY, Chancellor of the Institution.

JOSEPH HENRY, Secretary of the Institution.
SPENCER F. BAIRD, Assistant Secretary.
W. W. SEATON, Treasurer.
WILLIAM J. RHEES, Chief Clerk.

JAMES A. PEARCE, }
A. D. BACHE, } Executive Committee.
JOSEPH G. TOTTEN, }

REGENTS OF THE INSTITUTION.

H. HAMLIN, Vice-President of the United States.
ROGER B. TANEY, Chief Justice of the United States.
R. WALLACH, Mayor of the City of Washington.
JAMES A. PEARCE, member of the Senate of the United States.
W. P. FESSENDEN, member of the Senate of the United States.
L. TRUMBULL, member of the Senate of the United States.
S. COLFAX, member of the House of Representatives.
E. McPHERSON, member of the House of Representatives.
S. S. COX, member of the House of Representatives.
W. B. ASTOR, citizen of New York.
W. L. DAYTON, citizen of New Jersey.
GEORGE E. BADGER, citizen of North Carolina.
T. D. WOOLSEY, citizen of Connecticut.
ALEXANDER D. BACHE, citizen of Washington.
JOSEPH G. TOTTEN, citizen of Washington.

MEMBERS EX OFFICIO OF THE INSTITUTION.

ABRAHAM LINCOLN, President of the United States.
HANNIBAL HAMLIN, Vice-President of the United States.
W. H. SEWARD, Secretary of State.
S. P. CHASE, Secretary of the Treasury.
E. M. STANTON, Secretary of War.
G. WELLES, Secretary of the Navy.
M. BLAIR, Postmaster General.
E. BATES, Attorney General.
ROGER B. TANEY, Chief Justice of the United States.
D. P. HOLLOWAY, Commissioner of Patents.
RICHARD WALLACH, Mayor of the City of Washington.

HONORARY MEMBERS

BENJAMIN SILLIMAN, of Connecticut.
A. B. LONGSTREET, of Mississippi.
CALEB B. SMITH, Secretary of the Interior.

PROGRAMME OF ORGANIZATION

OF THE

SMITHSONIAN INSTITUTION.

[PRESENTED IN THE FIRST ANNUAL REPORT OF THE SECRETARY, AND ADOPTED BY THE BOARD OF REGENTS, DECEMBER 13, 1847.]

INTRODUCTION.

General considerations which should serve as a guide in adopting a Plan of Organization.

1. WILL OF SMITHSON. The property is bequeathed to the United States of America, "to found at Washington, under the name of the SMITHSONIAN INSTITUTION, an establishment for the increase and diffusion of knowledge among men."

2. The bequest is for the benefit of mankind. The government of the United States is merely a trustee to carry out the design of the testator.

3. The Institution is not a national establishment, as is frequently supposed, but the establishment of an individual, and is to bear and perpetuate his name.

4. The objects of the Institution are, 1st, to increase, and 2d, to diffuse knowledge among men.

5. These two objects should not be confounded with one another. The first is to enlarge the existing stock of knowledge by the addition of new truths; and the second, to disseminate knowledge, thus increased, among men.

6. The will makes no restriction in favor of any particular kind of knowledge; hence all branches are entitled to a share of attention.

7. Knowledge can be increased by different methods of facilitating and promoting the discovery of new truths; and can be most extensively diffused among men by means of the press.

8. To effect the greatest amount of good, the organization should be such as to enable the Institution to produce results, in the way of increasing and diffusing knowledge, which cannot be produced either at all or so efficiently by the existing institutions in our country.

9. The organization should also be such as can be adopted provisionally, can be easily reduced to practice, receive modifications, or be abandoned, in whole or in part, without a sacrifice of the funds.

10. In order to compensate, in some measure, for the loss of time occasioned by the delay of eight years in establishing the Institution, a considerable portion of the interest which has accrued should be added to the principal.

11. In proportion to the wide field of knowledge to be cultivated, the funds are small. Economy should therefore be consulted in the construction of the building; and not only the first cost of the edifice should be considered, but also the continual expense of keeping it in repair, and of the support of the establishment necessarily connected with it. There should also be but few individuals permanently supported by the Institution.

12. The plan and dimensions of the building should be determined by the plan of organization, and not the converse.

13. It should be recollected that mankind in general are to be benefitted by the bequest, and that, therefore, all unnecessary expenditure on local objects would be a perversion of the trust.

14. Besides the foregoing considerations deduced immediately from the will of Smithson, regard must be had to certain requirements of the act of Congress establishing the Institution. These are, a library, a museum, and a gallery of art, with a building on a liberal scale to contain them.

SECTION I.

Plan of Organization of the Institution in accordance with the foregoing deductions from the will of Smithson.

To Increase Knowledge. It is proposed—

1. To stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths; and
2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons.

To Diffuse Knowledge. It is proposed—

1. To publish a series of periodical reports on the progress of the different branches of knowledge; and
2. To publish occasionally separate treatises on subjects of general interest.

DETAILS OF THE PLAN TO INCREASE KNOWLEDGE.

I.—*By stimulating researches.*

1. Facilities afforded for the production of original memoirs on all branches of knowledge.
2. The memoirs thus obtained to be published in a series of volumes, in a quarto form, and entitled Smithsonian Contributions to Knowledge.
3. No memoir on subjects of physical science to be accepted for publication which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.
4. Each memoir presented to the Institution to be submitted for examination to a commission of persons of reputation for learning in

the branch to which the memoir pertains ; and to be accepted for publication only in case the report of this commission is favorable.

5. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision be made.

6. The volumes of the memoirs to be exchanged for the transactions of literary and scientific societies, and copies to be given to all the colleges and principal libraries in this country. One part of the remaining copies may be offered for sale ; and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

7. An abstract, or popular account, of the contents of these memoirs to be given to the public through the annual report of the Regents to Congress.

II.—*By appropriating a part of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects, and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects, so that, in course of time, each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made.

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, magnetical, and topographical surveys, to collect materials for the formation of a Physical Atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light ; chemical analyses of soils and plants ; collection and publication of scientific facts accumulated in the offices of government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America ; also, explorations and accurate surveys of the mounds and other remains of the ancient people of our country.

DETAILS OF THE PLAN FOR DIFFUSING KNOWLEDGE.

I.—*By the publication of a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. These reports will diffuse a kind of knowledge generally interesting, but which, at present, is inaccessible to the public. Some of

the reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch can procure the parts relating to it without purchasing the whole.

5. These reports may be presented to Congress for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoology, geology, &c.
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world, penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

II.—*By the publication of separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises should, in all cases, be submitted to a commission of competent judges previous to their publication.

3. As examples of these treatises, expositions may be obtained of

the present state of the several branches of knowledge mentioned in the table of reports.

SECTION II.

Plan of organization, in accordance with the terms of the resolutions of the Board of Regents providing for the two modes of increasing and diffusing knowledge.

1. The act of Congress establishing the Institution, contemplated the formation of a library and a museum; and the Board of Regents, including these objects in the plan of organization, resolved to divide the income* into two equal parts.

2. One part to be appropriated to increase and diffuse knowledge by means of publications and researches, agreeably to the scheme before given. The other part to be appropriated to the formation of a library and a collection of objects of nature and of art.

3. These two plans are not incompatible one with another.

4. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

5. The Institution should make special collections, particularly of objects to illustrate and verify its own publications.

6. Also, a collection of instruments of research in all branches of experimental science.

7. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found in the United States.

8. Also, catalogues of memoirs, and of books and other materials, should be collected for rendering the Institution a centre of bibliographical knowledge, whence the student may be directed to any work which he may require.

9. It is believed that the collections in natural history will increase by donation as rapidly as the income of the Institution can make provision for their reception, and, therefore, it will seldom be necessary to purchase articles of this kind.

10. Attempts should be made to procure for the gallery of art, casts of the most celebrated articles of ancient and modern sculpture.

11. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union and other similar societies.

12. A small appropriation should annually be made for models of antiquities, such as those of the remains of ancient temples, &c.

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* The amount of the Smithsonian bequest received into the Treasury of the United States is	$515,169 00
Interest on the same to July 1, 1846, (devoted to the erection of the building)	242,129 00
Annual income from the bequest	30,910 14

13. For the present, or until the building is fully completed, besides the Secretary, no permanent assistant will be required, except one, to act as librarian.

14. The Secretary, by the law of Congress, is alone responsible to the Regents. He shall take charge of the building and property, keep a record of proceedings, discharge the duties of librarian and keeper of the museum, and may, with the consent of the Regents, *employ assistants.*

15. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art; distinguished individuals should also be invited to give lectures on subjects of general interest.

This programme, which was at first adopted provisionally, has become the settled policy of the Institution. The only material change is that expressed by the following resolutions, adopted January 15, 1855, viz:

Resolved, That the 7th resolution passed by the Board of Regents, on the 26th of January, 1847, requiring an equal division of the income between the active operations and the museum and library, when the buildings are completed, be, and it is hereby, repealed.

Resolved, That hereafter the annual appropriations shall be apportioned specifically among the different objects and operations of the Institution, in such manner as may, in the judgment of the Regents, be necessary and proper for each, according to its intrinsic importance, and a compliance in good faith with the law.

REPORT OF THE SECRETARY.

To the Board of Regents:

GENTLEMEN: In the discharge of my official duty as the principal executive officer of the Smithsonian Institution, I have the honor to present to you a report of the operations of the establishment for another year.

It could scarcely be expected that during the existence of an intestine war, and almost in the presence of two contending armies, the Institution should be able to conduct its affairs with the same persistence and success as in the tranquil years of its previous history. The interruptions and embarrassments, however, although frequent, and in some cases perplexing, have not prevented the continuance of the general operations of the Institution, or the prosecution of most of the special objects which had previously been determined upon as falling within the scope of the plan of its organization.

At an early period of the war it was for a time proposed by the government to occupy the building of the Institution as temporary quarters of some of the troops which were suddenly collected in defence of the capital. In relation to this proposition, it was represented to the War Department that there was no authority from the Board of Regents to grant the use of the building for the purpose intended, but that if the Secretary of War thought proper to take possession of the premises on his own responsibility, the best arrangements possible to secure the property from injury and at the same time to accommodate the soldiers, would cheerfully be made. It was, however, suggested that if an appropriation for such a purpose were found to be necessary, it would be more in accordance with the spirit of the Institution to employ the building as an infirmary. Fortunately, there was judged to be no absolute necessity for the contemplated occupation, and neither the building nor the grounds around it have been occupied for military purposes. In this, as in other instances, the government has evinced a considerate desire to protect the property of the Institution and to foster its operations.

It has been lately stated in a foreign journal, and the statement has

been widely copied in this country and in Europe, that the bequest of Smithson had been lost by improper investment; but those who are acquainted with the history of the establishment know that this statement is without the slightest foundation in fact. The government of the United States in accepting the bequest upon the stipulated terms of the will, became, by an act of Congress, approved by the President, the trustee of the fund and guardian of the Institution. The agent appointed to receive the money brought it to this country in British gold, and deposited it in the United States mint in Philadelphia, where it was recoined into American eagles. The government thus became, by express enactment as well as by the highest equitable considerations, responsible for the security of the funds as well as for the faithful administration of the trust. It is true that the Secretary of the Treasury, before the money had been permanently invested by Congress, lent it to several of the western States to assist in carrying on their works of internal improvement; but it would have been alike inconsistent with strict justice and the liberal policy of our government, to devolve on the Smithsonian fund any risk or loss which might result from this financial operation. Congress, therefore, declared, by a joint resolution, that the money of the bequest was to be considered as a fund lent to the Treasury of the United States, the interest of which, at the rate of six per cent. per annum, is to be applied to the perpetual support and maintenance of the Institution. It is proper to state in this connexion that the government itself will in time, probably, be reimbursed for the money advanced to the States, since, in accordance with a rule established by the Hon. Robert J. Walker, when Secretary of the Treasury, all money received in the Treasury on account of the States to which the loan was made is to be retained until the debt of each is fully satisfied. In this way nearly four hundred thousand dollars have already been received.

Not only does the original fund of Smithson thus remain safe and unimpaired in the treasury of the United States, but, after paying for the building, collecting a library and museum, and conducting all the operations which have given character to the establishment, out of the income; an extra fund has been accumulated from the interest itself, which, at the date of the last report, yielded seven thousand seven hundred and sixteen dollars.

Unfortunately, a part of this fund has been unproductive during the past year. A petition from the Board of Regents was presented

to Congress at two successive sessions requesting that the extra fund which had been thus economised might be received into the treasury of the United States, and form a permanent addition to the original deposit. The proposition was favorably commended to Congress by a report of the committees to which it was referred, but from the pressure of business the recommendation was not acted on, and the directors of the establishment were obliged to seek some other investment of the money. State stocks naturally presented themselves as apparently offering the safest means of accomplishing the desired object, and accordingly a committee of the Board decided upon the purchase of bonds of the States of Indiana, Virginia, and Tennessee. About $63,000 were expended in the purchase of the State stocks of Indiana, $50,000 in those of Virginia, and $11,000 in those of Tennessee. It is scarcely necessary to state that no interest has been received from Virginia and Tennessee since the date of the last report, and it is not probable that anything will be obtained from them for some years to come. The other sums invested in State stocks have yielded the usual amount of interest. The Virginia stock is still rated at 50 per cent. of its par value, and we trust that the State will, in time, be again able to discharge her obligations to this Institution; but in the interim there will be on this account a diminution in the annual income of nearly four thousand dollars.

As an offset to this effect of the unforeseen condition of the States above-mentioned, information has been received from London of the death, at an advanced age, of Madame De la Batut, the mother of the nephew of James Smithson, to whom an annuity was conceded as a compromise by the Hon. Richard Rush, with a view to the more expeditious realization of the Smithsonian legacy. The principal of this annuity, amounting to five thousand and fifteen pounds (about $25,000) will now be added to the bequest of Smithson, of which it originally formed a part.

It has been considered advisable, in view of the distracted state of the country and the failure of the States before-mentioned to pay their interest, to curtail the expenditures of the Institution, as far as practicable, without suspending what have been denominated the *active* operations. Yet, while this cautious policy has been closely observed, it is believed that the Institution has sustained its character for efficiency, and that, although it has been exposed to the disturbing incidents of a theatre of war, it has still accomplished much during the year, and steadily advanced in the career prescribed by

its enlightened founder—the increase and diffusion of knowledge among men.

Publications.—The thirteenth volume of the Smithsonian Contributions is partly completed, but, on account of the unsettled condition of the times, it was thought prudent to delay the printing of several expensive papers until the beginning of the present year. It will be seen, however, in the course of this report, that the whole number of pages of printed matter which has been issued, or is now ready to be issued by the Institution, equals that of any previous year.

The first paper which has been printed for the thirteenth volume is the concluding part of the results of the discussion of the observations of Dr. Kane, fully described in the last report. On the completion of this series of papers, a number of full sets of the several parts have been bound, with a general title page, into a separate volume, which is intended for distribution to astronomical and meteorological societies to which the contributions in full are not presented.

Another series of papers, partly printed, gives a full discussion of all the meteorological observations made during the voyage of Sir F. L. McClintock, in search of Sir John Franklin, in the English steamer Fox, from the 1st of July, 1857, to September, 1859.

The records of these observations were presented by the commander of the expedition to the Institution for discussion and publication, in accordance with the plan adopted for those of Dr. Kane; and since they relate to the meteorology of this continent, and are the results of a private expedition, it was thought entirely consistent with the policy of the Institution to discuss and publish them at the expense of the Smithsonian fund. It would be of great interest to science, and particularly to the meteorology of this country, if all the observations which have been made in the Arctic regions were reduced and discussed on a uniform plan, like that adopted in regard to the observations of Dr. Kane. A correspondence has been commenced with the proper authorities in England in regard to the importance of such a work, offering the co-operation of the Institution in carrying it into execution.

In regard to the history of the observations made during the voyage of the "Fox," the following facts may be stated:

The last expedition of the British government in search of Sir John Franklin returned in 1854, without doing more than confirming what

had previously been ascertained—that the missing ships had spent their first winter at Beechy island. Later in the same year the celebrated traveller of the Hudson's Bay Company, Dr. Rae, ascertained that the missing voyagers had been seen on the west coast of King William's land in the spring of 1850, and that it was supposed they had all died on an estuary of the Great Fish river.

The attempts, in 1855, of the Hudson's Bay Company to explore this river resulted in obtaining but little additional information and a few relics from the Esquimaux. It was at this time that Lady Franklin, who had previously sent out three expeditions, again urged the renewal of the search, that the fate of her husband and his companions might not be left in uncertainty. She, therefore, undertook once more the responsibility and expense of a final effort to "follow their footsteps in their last journey upon earth," and if possible to give to the world the scientific results of the expedition for which these gallant men had probably sacrificed their lives. In the spring of 1857 Lady Franklin commenced the preparations for the contemplated expedition, and intrusted the command of it to Captain McClintock. The small steamer "Fox," of 180 tons register, was purchased for the service, and was put in readiness by the end of June. The expedition sailed from Aberdeen July 1, 1857, and after a favorable run across the Atlantic, passed Cape Farewell, the southern point of Greenland, on the 13th of July, and arrived at Fredericshaab on the 19th of the same month. After taking in coal at Waigat, they arrived at Upernavik, and then bore away on the 6th of August directly westward, for the purpose of crossing Baffin's bay, but on the evening of the 8th their progress in that direction was stopped by impenetrable ice in latitude 72° 40′ and longitude 59° 50′. They then steered to the northward, in the hope of finding a passage westward, but in this they were disappointed, and, on the 19th of August, became entangled in the ice, and thus remained 242 days, until April, 1858. During this period the "Fox" drifted from latitude 75° north and longitude 62° west, to latitude 63° 40′ north and longitude 59° west, or 1,385 statute miles in a southeasterly direction, almost to the lower extremity of Greenland.

On the 26th of April the ice suddenly and almost entirely disappeared, and the ship was again headed northward for another attempt, and arrived on the 19th of June in Melville bay, and thence again steered westward across Baffin's bay, and finally entered Lancaster sound in the beginning of August. They thence sailed westwardly

and southerly until they reached the longitude of 96° west; thence returned along Barrow's strait to the east, and southerly down Prince Regent's inlet to the mouth of Bellot strait, where, at a place named Port Kennedy, the vessel remained from the 27th of September, 1858, till August 9, 1859. From this point various excursions, with sleds, were made in different directions. The expedition returned to England in September, 1859.

During the whole continuance of the expedition a series of meteorological and other observations was made. Those of the first year were taken while the vessel was in a constant state of motion either sailing through the water, or drifting down Baffin's bay with the immense field of ice. Those of a considerable part of the second year were made while the ship was stationary at Port Kennedy.

The observations have all been arranged in four parts: the first relating to temperature; second, to winds; third, to atmospheric pressure; fourth, to miscellaneous phenomena, such as auroras, weather, specific gravity of sea-water, ozone, &c.

In the discussion of the records, the whole series has been divided into two groups, one of which is referred to a point in Baffin's bay, and the other to Port Kennedy.

The discussion of the temperatures of each group embraces—

1st. Diurnal variation.
2d. Annual variation.
3d. Relation of temperature to the phases of the moon.
4th. Temperature of different winds.
5th. Temperature of sea-water.

The discussion of the winds includes—

1st. Resultant direction for each month, season, and year.
2d. Velocity for each of these periods.
3d. Frequency of winds from different quarters.
4th. Quantity of air which passed over the station.
5th. Rotation of the winds.
6th. Investigation of particular storms.

A similar series of discussions is also given with regard to the barometer. These discussions have all been made at the expense of the Institution by Charles A. Schott, of the Coast Survey, according to the methods adopted by Sir John Herschel, in his admirable article on meteorology in the last edition of the Encyclopedia Britannica. They bring out a number of interesting results, particularly in regard to the rotation of the wind, the effect of the moon on the temperature, and the

connexion of changes of the weather in the arctic regions with those in the more southern latitudes of the continent of North America.

The observations for temperature were made at equal intervals day and night; in winter they were generally taken every two hours, in the summer every four hours. The register extends over twenty-seven months, and comprises a total number of 7,113 observations.

The highest monthly mean temperature occurred in July. In the first year, 1857, in latitude 62°, it was 45°.53. In the second year, (1858,) in latitude 74°.4, it was 36°.60. In 1859, latitude 72°, it was 40°.12. The lowest monthly mean temperatures were in January. That in 1858, in latitude 73°.2, was —24°.87. The second, that in 1859, in latitude 72°, was —33°.57.

The mean annual temperature of the year, as deduced from all the observations at Port Kennedy, in latitude 72°, was 1°.85. The highest temperature observed at the same place was 55°, which occurred July 29, 1859, and the lowest —49°.8, January 21 and February 15 of the same year.

The extreme range, therefore, was 104°.8.

The highest temperature observed by Kane at Van Rensselaer harbor, in latitude 78°.37, was 51°, and the minimum —66°.4, giving a range of 117°.4

The greatest daily range of temperature was in June, amounting to 9°.60; the least in December, when it was 0°.84. At Van Rensselaer harbor, the greatest range occurred in April, and was 9°.09; and the least in November, amounting to 1°, showing a correspondence in amount of variation, but not in time.

On an average, the maximum temperature is reached between noon and 1 p. m., and the minimum between 2 and 3 a. m.; whereas at Van Rensselaer harbor, as observed by Dr. Kane, these hours were respectively 2 p. m. and 1 a. m.

One of the most interesting points of the discussion of the observations is that of the connexion of the phases of the moon with the low winter temperatures. This connexion was early suggested by arctic explorers, and was independently deduced from the observations by Kane. In order to investigate the question of this connexion the mean daily temperatures were divided into periods of five days, thus forming a table in which the dates of the occurrence of full and new moon are given with the corresponding mean temperatures. By taking the differences of the mean temperatures it is seen that the mean temperature is lower at full moon than at new moon by about

$7\frac{1}{4}$ degrees. This difference is less than that deduced from the observations of Kane at Van Rensselaer harbor, but of the same kind, and serves to establish the fact of the occurrence of maximum cold at the period of full moon. Mr. Schott, in his paper on the discussions of Kane's observations, has referred this cold to a secondary action. The moon, as is now established by direct experiment, radiates and reflects a considerable amount of heat to the earth, which is of the kind called dark heat, or that of such low intensity as to be readily absorbed by the vapor of our atmosphere, and particularly by clouds. The effect, therefore, of the full moon is to dissolve the clouds, and thus to give freer passage to the radiated heat from the earth into celestial space.

In order, however, that this explanation should be true, it is necessary that the heat from the moon should be more penetrating and have more effect upon the clouds than that from the earth; and that this is the case is not improbable, as a part of the heat from the moon is that reflected from the full meridian sun, while that given off from the earth is merely due to its own nocturnal radiation.

It is not probable, as we have stated in a previous report, that an equal difference of temperature at the time of new and full moon will be observed in middle latitudes, for, from the observations made at this Institution, the waves, as it were, of cold which reduce the temperature of the United States, frequently begin several days earlier at the extreme west; and hence while the full moon occurs nearly at the same moment of absolute time at all places on the surface of the earth, the maximum cold might occur in one place at the new, and in another at the full moon. In the arctic regions, on the other hand, where the moon is at the same moment visible from every meridian, the effects of its heat must be more perceptible and less masked by the operation of other causes. In the observations of a long series of years, however, the difference may, perhaps, be rendered manifest, even in the latitude of Washington.

Professor Dove, of Berlin, has called attention to the remarkable recurrence of cold about the 11th of May of each year, but nothing of this kind can be deduced from the observations during the voyage of the "Fox," although from the observations by Kane at Van Rensselaer harbor on the 13th of May, 1854, the temperature was 9°.3 lower than that computed for the mean of the same day at the same place.

The diminution of temperature at this period is evident from the

observations for long series in this country as well as in Europe, and has been attributed to some cosmical influence affecting the absolute amount of heat received by the earth at this time.

The deductions relative to the elevating and depressing influence of the wind upon temperature, show that in Baffin's bay the southeast winds are the warmest, and the southwest the coldest, and that the temperature is lowest during calms.

They show, also, that at Port Kennedy the east winds are the warmest, and the north winds the coldest; there, also, calms are attended with a depression of temperature.

Observations were made upon the temperature of the soil, by sinking a brass tube two feet two inches vertically into the ground. A padded thermometer was inserted in the tube, and the whole was covered with snow. The temperature in the external air was lowest about the 19th of January, and that in the tube about the 10th of March, when it reached $+ 5°$. Hence the greatest cold in the ground at a depth of a little more than two feet occurred fifty-seven days later than at the surface.

In discussing the observations relative to the winds, the whole period, as in the case of the discussions of temperature, is divided into two parts—the first when the Fox was in Baffin's bay, and the second when she was at Port Kennedy. The number of daily observations varied from six to twelve; in all cases, however, at regular intervals. The method of reduction is that of Lambert, improved by Herschel and others, so as to include the velocity of the wind, and not merely the relative frequency.

The amount of wind, as estimated by the continuance and velocity from all directions, was resolved, plus and minus, into two directions—one, that of the meridian, and the other at right angles to it; and from these two components a resultant was deduced for each month, giving the average direction from which the wind came. In this discussion Mr. Schott assumes the south point of the horizon as the zero point, because azimuths in astronomy are read in this way, and he prefers reckoning from the south to the west, rather than from the south to the east, because the wind-vane is found to rotate more frequently in the former direction.

The great variation in the direction and force of the atmospheric currents renders the calculation of resulting values for shorter intervals than a month unnecessary. At Port Kennedy the resulting direction of the wind is remarkably constant for different seasons.

In winter it is northwest by north; in summer north $\frac{3}{4}$ths of a point west; for the whole year, N.NW$\frac{3}{4}$W. The corresponding directions for Baffin's bay are nearly the same, and the final resultant direction for the year at the two localities are practically identical.

In the first year, while in Baffin's bay, the velocity of the wind was greatest in February and March, and least in June and July. In the second year, at Port Kennedy, it was greatest in October and November, and least in March and April.

The greatest amount of wind, both at Port Kennedy and Baffin's bay, was from the northwest, in accordance with the theory of the descent or sinking down of the heavier air in the colder regions, and its flowing thence to warmer portions of the earth. For the purpose of ascertaining the law of the rotation of the winds, the records were examined in reference to the number of times the vane arrived at each of the eight principal points, and also in reference to the sum total of angular movement in a direct and retrograde direction.

From this investigation it appears that the direction of the shifting of the wind in spring was direct; at other seasons retrogade, and that the total amount of angular motion in the course of a year was very nearly balanced.

At Rensselaer harbor the resultant rotation of the wind was found to be direct, and this was also the case in Baffin's bay, although it would appear from these discussions, that the law of the rotation of the wind which has been found to prevail in lower latitudes, does not hold with the same constancy in the arctic regions.

In the year 1857–'58, in Baffin's bay, there were 26 storms of an average duration of 19 hours; in these storms the prevailing winds were, almost to the exclusion of all others, from the northwest and southeast. At Rensselaer harbor, according to Kane, the winds during the prevailing storms were from the same points of the horizon. At Port Kennedy during the year 1858–'59 there were 22 storms recorded, in which the wind was from the northwest; in a few cases it was from the northeast; but in not one from the northwest or southeast.

The third part of the McClintock observations relate to the pressure of the atmosphere. These observations were recorded at equal intervals of two hours at one period, and of four hours at others. They were made with a mercurial barometer, and also with an aneroid.

The records of the readings of the two instruments were compared,

and from them a correction obtained to be applied to the aneroid. The differences appear remarkably regular, and show that the mean monthly readings of the aneroid may be relied on to the hundredth of an inch. The average correction was found to be .022 of an inch, a quantity which, strictly speaking, is composed of two parts, namely: of the true index error of the aneroid, and the specific differences of the two instruments in different latitudes. In the mercurial barometer a mass of metal is balanced against a mass of air, and, therefore, the indications are independent of a change of gravity, for the same reason that a pound weight in an ordinary scale balance is in equilibrium with the same amount of the material weighed, in whatever latitude the experiment may be made. Not so, however, with the aneroid barometer; as this instrument, like the spring balance, indicates the pressure by the reaction of an elastic material, it must be affected by a change in gravity, and consequently varies in its indications with a change of latitude.

The diurnal variation in the pressure of the atmosphere in the higher latitudes of the arctic regions is very small, and can only be satisfactorily traced by means of the combination of a great number of observations, while the fitful variations in the atmospheric pressure are frequently very large.

The minimum pressure both at Baffin's bay and at Port Kennedy occurred at about half after four o'clock a. m., and the maximum at about half-past seven o'clock p. m. The range of the diurnal fluctuation in Baffin's bay is .028, at Port Kennedy .048, and at Rensselaer harbor .010. There is, therefore, a diminution in the range as we go northward, and at the same rate diurnal variations would become insensible at about 80° of latitude.

The average height of the barometer varies in different months of the year; it is greatest in April and May.

The occurrence of the minimum is not simultaneous at the different stations; at Baffin's bay it was in January, at Port Kennedy in July, and at Rensselaer harbor in September, presenting results which clearly indicate that more observations are required to fix with precision the time at which it really takes place. The annual range of the barometer at Baffin's bay was .44, at Port Kennedy .41, and at Rensselaer harbor .21.

The relative pressure connected with different winds is also given. In Baffin's bay the north wind gave a maximum pressure; at Port Kennedy, and also at Rensselaer harbor, the south wind produced

this effect. In Baffin's bay the minimum pressure accompanied the southeast wind, while at Port Kennedy the same effect was produced by the northeast wind, and at Rensselaer harbor by the west and northwest. The lowest reading of the barometer occurred just before the commencement of violent storms.

Among the miscellaneous observations, perhaps the most important is one which relates to the aurora borealis. Captain McClintock observed that the streamers in all cases of the exhibition of this meteor appeared to come from the surface of open water, and not in any case from the fields of ice. This observation would go far to establish the truth of the hypothesis that auroral displays are due to electrical discharges between the air and the earth, and that these are interrupted by the interposed stratum of non-conducting ice.

On the occasion of a visit of Lady Franklin last summer to the Smithsonian Institution, I had the satisfaction of receiving, on behalf of the Regents, her expressions of thanks for the discussion and publication of these observations, connected as they are with the memory of her lamented husband.

Another paper which has been accepted for publication is entitled "Ancient Mining on the Shores of Lake Superior." This paper was received in July, 1856, but, owing to imperfections in the manuscript, its publication was indefinitely postponed. The subject, however, of which it treats has lately received so much additional interest from the investigations of the archæologists of different parts of Europe that we were induced to submit it again to the author for correction, and to have a more accurate map of the mining region prepared, as well as corrected drawings of the implements made, under the immediate superintendence of the Institution. The wood-cuts are now in the hands of the engraver, and the memoir will be prepared for distribution without unnecessary delay.

On reference to the first volume of "Smithsonian Contributions" it will be seen that among the contents of the mounds of the Mississippi valley, as figured by Squier and Davis, are implements and ornaments of copper, such as axes, chisels, knives, spear heads, rings, bracelets, &c. The copper of these articles frequently contains small portions of pure silver—perhaps originally in the form of crystals—which serve in a measure to identify the source from which the material came. Pure copper is comparatively a rare mineral, and nowhere on the surface of the earth has it been found in greater quantity and in larger masses than in that remarkable projection from

the southern shore of Lake Superior, called Keweenaw Point. Through the whole of this peninsula a band of metalliferous deposit extends more than a hundred miles in length, and from one to six miles in width. Within this band pure copper is found in immense masses, also in thinner veins and small boulders.

The Jesuit missionaries as early as 1636 mentioned the existence of copper in this region; their knowledge, however, was probably restricted to small pieces of copper found in the streams. The first actual attempts at mining in this region within historic times were made in 1791, by Alexander Henry, but it was not until about 1842 that active and successful operations were undertaken.

Previous to this period pits and small mounds of earth had been observed in the metalliferous region; but it was only in 1848 that these were discovered to be remains of ancient excavations connected with the mining of copper. After this fact was clearly ascertained, it was turned to a profitable account by modern explorers, who found that their predecessors had industriously ferreted out the rich lodes, and that copper was always to be found by the indications of the ancient "diggins," as these excavations are popularly called. The ground is mostly covered with a dense forest, and, in many cases, with fallen trees of a preceding growth, indicating a great lapse of time since the excavations were made. The present Indians of the region have no knowledge of the origin of these remains, or of the purpose with which they were connected. The implements employed by the ancient miners were those which European archæologists refer to what they call the stone age, and to the transition period denominated by them the bronze age. They consist of mauls and adzes of trap rock, and chisels of flint and of copper. Fire was not employed to melt the metal, but apparently to assist in disintegrating the rock. Levers of wood were used for elevating large masses, but with the implements mentioned the earth could only be penetrated to a short distance. For cutting wood, copper chisels and probably adzes and axes of the same metal were employed. The copper was hardened by hammering when cold, and not in any case by admixture with other metals. The primitive miners were unable to manage large masses, and consequently sought for lumps which could be readily beaten into the required shape.

The Lake Superior mining region does not appear to have been the place of permanent residence of a large number of tribes, for no

human remains or sepulchral mounds have been discovered, nor any evidence of the cultivation of the soil. From the extent of the works, and the difference in their apparent antiquity, it is probable that a large number of individuals were engaged, and during a long succession of years.

Miscellaneous Collections.—The Miscellaneous Collections include works intended to facilitate the study of the various branches of natural history, to give instruction as to the method of observing natural phenomena, and a variety of other matter connected with the progress of science. Although the object of the Institution is not educational, yet in carrying out the general plan it has been thought important in some cases to publish elementary treatises, which will not only furnish an introduction to special subjects to those who have not access to expensive libraries, but also serve to point out the way in which individuals by special studies can not only promote their own enjoyment, but also co-operate with all others engaged in the same pursuit in extending the domain of knowledge. The objects of nature, like the specimens of high art, are the luxuries of the cultivated mind, and the awakening of a taste for their study affords an inexhaustible source of pleasure and contentment to the most numerous and the most important classes of the community.

In accordance with this view it was stated in the last report that the following works were in preparation to introduce and facilitate the study of *conchology*, a branch of natural history not only interesting in itself, but also indispensable in the study of geology, as the ages and relative position of rocks are principally determined by the remains of this class of animals, which are found imbedded in their strata:

1st. Elementary introduction to the study of conchology, by P. P. Carpenter, of England.

2d. List of the species of shells collected by the United States exploring expedition, by the same author.

3d. Descriptive catalogue of the shells of the west coast of the United States, Mexico, and Central America, by the same author.

4th. Bibliography of North American conchology, by W. G. Binney.

5th. Descriptive catalogue of the air-breathing shells of North America, by the same author.

The first of these works was published as a part of the appendix to the report of the Regents for 1860, and, in order to meet the

special demand for the article, 1,000 extra copies were struck off in pamphlet form for separate distribution. To illustrate this work we have been promised by Dr. Gray, of London, a series of stereotype casts from the wood-cuts used in the British Museum catalogues. They were not received in time to be inserted in the report. We shall, however, distribute copies of them to all persons who have received the work in a separate form.

Mr. Carpenter, the author of these lectures, who is well known to the students in this branch of natural history, has presented in this work an account of the present condition of our knowledge of the molluscous animals, and completed a task which will go far to supply a want which has been experienced by all who have commenced the study of these objects. The only other popular introductory work on shells in the English language of a reliable and representative character, is Woodward's Manual of the Mollusca, from which it differs in some essential particulars, which better adapt it to the object intended. It includes an account of the extinct as well as the recent forms. The families and higher groups as well as the genera are necessarily very briefly characterized, but sufficiently so to enable the student, with perseverance and study, to identify the species and recognize their affinities. One of the best features of the work, and which will interest the accomplished naturalist as well as the elementary student, is a table of apparently similar shells belonging to different families or genera; or of shells whose general appearance is similar, but which, on account of more important characters, are separated into widely different genera. It is also proper to remark that the work is not confined to a description of the external covering of the animals, but also includes that of their soft parts.

The other numbers of the above-mentioned series of works on conchology are still in course of preparation, and will be published as soon as they are completed.

It was also mentioned in the last report that a series of articles was in preparation to facilitate and promote the study of the *entomology* of North America. This branch of general zoology is perhaps larger than that of all the other branches taken together. In order to illustrate this statement we may mention, on the authority of Baron Osten Sacken, to whom we are specially indebted for advice and direction in regard to the best means of promoting this object, that according to the most recent computations, the number of species of insects in all parts of the world, is believed to be rather above than below one

million five hundred thousand, a considerable portion of which there is reason to suppose may be found in North America. To collect, arrange, and study such a vast number of objects requires a corresponding number of co-laborers; but fortunately for the advance of entomology, wherever a taste for it has been awakened, its votaries outnumber those of almost any other branch of natural history. There is scarcely one, says Osten Sacken, which offers equal facilities to the student who prosecutes its study—scarcely one which is so apt to become a favorite with every class of persons; and there is none, even botany not excepted, in which the mere gratification of taste can be so well combined with real scientific usefulness. It is adapted to every condition of life, because the specimens take up very little space, and require but trifling expense in collecting them; to every degree of education, for the number of insects being inexhaustible, any schoolboy may make collections or observations of great value to the more scientific investigator; it can be combined with almost any other pursuit, and can at any time be laid aside to be resumed at a more favorable moment.

Advancement of knowledge, however, naturally precedes its diffusion; therefore, before attempting to awaken a taste for the pursuits of entomological studies, it was necessary to bring this branch of natural history, as far as it relates to this continent, to a greater degree of perfection than that to which it had attained. American entomology is in this respect, as we are informed, far behind American botany. The systematical knowledge of the plants indigenous to the settled parts of North America is almost brought to perfection, and excellent manuals have been prepared, making it comparatively easy, even for a beginner, to identify most of the plants he may find. Not so with entomology; by far the greater number of our insects are still undescribed. The publications on American entomology are scattered through a great number of scientific transactions, most of which are in foreign languages, and therefore inaccessible to the many who would otherwise be interested in the study.

The first object of the Institution was, therefore, to collect and present in a compact and condensed form the existing knowledge; next, to increase this knowledge by encouraging further research by scientific men, so as to bring this branch of science to a certain degree of completeness and of symmetry in its different parts, and not until after this was accomplished to attempt its general diffusion. This

plan has been strictly pursued in the successive entomological works undertaken for the Institution, as will appear from the following account.

1. Among all the orders of insects which are found on the continent of North America, the Coleoptera (beetles) were the best known, owing principally to the exertions of Dr. Le Conte, of Philadelphia. What was wanted as regards this order for popular purposes was less the *increase* of knowledge than the condensation above alluded to. This has been aimed at in two publications by the Institution, namely, Melsheimer's Catalogue of the Coleoptera of the United States, revised by Haldeman and Le Conte, and published in 1853, and the Classification of the Coleoptera of North America, by Dr. Le Conte. The first part of the latter appeared in 1861, and the second will be issued soon. The first of these works facilitated research by furnishing a list of all the described species, with references to the works or scientific transactions containing them. The second will give a thorough and detailed account of the systematical distribution of the Coleoptera of this country, and thus offer to the student a faithful delineation of the present state of the science, and to the beginner a welcome hand-book for its acquisition.

2. The Lepidoptera, (butterflies, moths, &c.,) have always been, like the Coleoptera, a favorite order of insects, and a considerable number of descriptions of North American species was scattered through various works, transactions, &c. It was decided, therefore, to issue first, a list of these species, with references, on the plan of Melsheimer's catalogue of Coleoptera; next, a republication in a compact form of all these descriptions in English. Both these works were prepared, at the suggestion of the Institution, by Dr. Morris, of Baltimore, and published, the one as a catalogue, in 1860, the other as a synopsis of the described Lepidoptera of North America, in 1861. The latter will save to the lepidopterist much trouble and expense, by giving him in one volume what he would have had to look for in more than fifty different publications.

3. The order of Neuroptera (dragon flies, may flies, lace-wings, &c.,) contains, comparatively, a small number of species, and for this reason it was possible to produce at once a more perfect and thorough work on this order than has yet been prepared on any other. The synopsis of the Neuroptera of North America, with a list of the South American species, published in 1861, was prepared, at the request of the Institution, by Dr. Hermann Hagen, of Konigsberg, one of the

first contemporary authorities in this branch, and principally from materials furnished by or through the medium of the Institution. It contains the description of 716 North American and a list of 507 South American species. The plan of this publication is essentially different from that of the synopsis of Lepidoptera, the latter being a mere compilation of existing descriptions, whereas the greater part of the descriptions contained in the former were drawn by Dr. Hagen from specimens in his possession, and thus the necessary uniformity and accuracy have been secured. The original manuscript in Latin was translated into English and prepared for publication by Mr. Ph. R. Uhler, of Baltimore.

4. The order of Diptera, (flies, mosquitoes, &c.,) is known to be exceedingly numerous and of rather difficult study, as much on account of the minuteness and great fragility of most of the species as of a peculiar inconstancy and comparative slightness of the characters used for classification. In this case, as in preceding ones, the first work directed by the Institution was one of condensation, namely, the Catalogue of the described Diptera of North America, by Baron Osten Sacken. It was published in 1858, and includes a list of about 1,700 species, with references to ninety-five works and papers containing their descriptions, principally in foreign languages.

The next thing to be done was either to furnish a republication of all these descriptions, like that of the synopsis of Lepidoptera, or to attempt at once to prepare a monograph of the order. Owing to the large collections formed by Baron Osten Sacken during his residence in this country, the latter was possible. It was deemed advisable to put these collections into the hands of Dr. H. Loew, of Meseritz, Prussia, one of the most eminent dipterologists now living, who will prepare a series of monographs on the different families of this large order, to be published by the Smithsonian Institution. The first volume of this series is now in the press.

It may be proper here to call attention to the great importance of having the first foundation of a study laid by the most eminent authority. This is especially necessary in regard to the Diptera, since, as we are informed, this class of American insects contains a great number of species, closely allied to European species, and consequently requires an intimate knowledge of the latter to identify the former. Besides this, there are many insects of the same class in this country altogether different from those of Europe, which will require the formation of new genera, a work which can only be prop-

erly done by one intimately acquainted with the entire subject. Dr. Loew has found, for instance, that a genus (Paralimna Fab. Hydromysidae) occurring in North America, and foreign to Europe, had been also discovered in Africa, and previously described. Almost any one but Dr. Loew would have formed a *new* genus of this insect, and the interesting fact of the occurrence of the same genus in Africa and America, and not in Europe, would have been, for a time at least, unknown to science. Some other curious results have been obtained by this naturalist from the study of Baron Osten Sacken's collections. A species of *borborus*, from Cuba, has been found identical with an African species, and from the matter on which this fly occurs (alvine dejections) it is probable that it has been accidentally imported into that island by a slave ship. A still more interesting result is the discovery of the striking analogy between the present American and the fossil tertiary fauna, coinciding with the analogy of the corresponding floras. Dr. Loew having monographed the fossil Diptera preserved in Prussian amber, and having described no fewer than 656 of such species, was better able than any one else to trace this analogy. The remarkable fact appears from his investigation that insects, some of them very singular, which are absolutely extinct in Europe, are now found living in America.

Such have been, up to the present time, the entomological publications of the Smithsonian Institution. They do not as yet embrace the three orders of *Hemiptera*, *Orthoptera*, and *Hymenoptera*. Mr. Ph. R. Uhler, of Baltimore, who has for several years made the North American Hemiptera (tree bugs, plant lice, &c.,) the special subject of his study, is preparing for the Institution a work in regard to these insects on the same plan as that of Hagen's Neuroptera, which it is expected will be soon ready for publication.

Little has yet been done for the *Orthoptera*, (grasshoppers, rear horses, crickets, &c.,) although, owing to the small extent of this order, it would be a comparatively easy task to produce a work similar to the synopsis of Neuroptera, if a sufficient collection of specimens were in existence. The Institution has adopted measures to have this desideratum supplied. The study of North American *Hymenoptera* (bees, wasps, &c.,) was undertaken several years ago by Mr. H. de Saussure in Geneva, and large collections have been furnished to him by the Institution. It is expected that his manuscript will soon be furnished for publication.

In order to complete the series of the entomological publications of the Institution, a want of the intelligent public remains to be supplied, that of a popular work on Entomology in general, designed to serve as an introduction to this department of zoology, and to facilitate its acquisition by presenting its elements in an attractive form, while at the same time infusing the true philosophical spirit of the science. Such a work is in contemplation, and will promote more than any other the diffusion of this branch of knowledge.

Reports.—The next class of publications consists of the annual Reports to Congress. These reports, which are printed at the expense of the Government, consist each of an octavo volume, limited to 450 pages. They contain the report of the Secretary, the acts of the Regents, and an appendix, consisting of a synopsis of lectures delivered at the Institution, extracts from correspondence, and information of a character suited to the meteorological observers, teachers, and other persons especially interested in the promotion of knowledge. The appendix to the report for 1860 contained three lectures of a course on Roads and Bridges, by Prof. Fairman Rogers, the remainder of which will be given in the report for 1861; an extended series of lectures on Mollusca or Shell-fish, and their allies, by Philip P. Carpenter; general views on Archæology, by A. Morlot, translated from the French; a series of articles translated from foreign journals; and extracts from correspondence, principally on meteorology and natural history.

Of this report 10,000 extra copies were ordered by Congress, of which 4,000 were presented to the Institution for distribution among its special correspondents. The requests for this work have been constantly increasing, and the demand for back numbers to complete sets has been greater than the Institution could supply.

The following general rules for the distribution of these reports have been adopted:

1st. They are presented to all the meteorological observers who send records of the weather to the Institution.

2d. To the collaborators of the Institution.

3d. To donors to the museum or library.

4th. To colleges and educational establishments.

5th. To public libraries and literary and scientific societies.

6th. To teachers, or individuals who are engaged in special studies, and who make direct application for the volumes.

The additional distribution of copies of these reports by Congress serves still more widely to make known the character and operations of the Institution, and to diffuse a species of useful knowledge which cannot otherwise be readily obtained.

Ethnology.—From the previous reports it will have been seen that the Institution has endeavored to promote various branches of the science of ethnology. Besides the works on Indian Archæology, it has presented to the world several papers which relate to language. In the report for 1860 a list of original manuscripts was given, relating to the languages of the western coast of North America, which had been received through the assistance of Mr. Alexander S. Taylor, of Monterey, California. Several of these have been carefully copied, at the expense of the Institution, with the intention of insuring their preservation and their subsequent publication. It has been suggested that the publication of a grammar and dictionary of one at least of each of the representative languages of North America would much facilitate the investigation of the general relations of the several parts of this branch of ethnology. With a view to carrying out this suggestion, means have been adopted to obtain information as to all the manuscripts which may possibly exist; and we have been so fortunate as to enlist the co-operation, in this important work, of a number of valuable collaborators. Among these are Mr. Alexander S. Taylor, of California; the Catholic clergymen of the western coast of North America; Mr. George Gibbs, of Washington Territory; Mr. Buckingham Smith, late Secretary of Legation to Spain, and Mr. J. G. Shea, of New York.

Mr. Shea, who has devoted much attention to the subject of comparative philology, has commenced the publication at his own expense of a "Library of American Linguistics," which he is desirous of continuing as a labor of love; and since it would not be in accordance with the policy of this Institution to interfere with so praiseworthy an undertaking, but on the contrary to facilitate it by all the means in its power, it has been thought proper to present to Mr. Shea copies of all the collections which the Institution has yet made relative to this subject, and to purchase from him for distribution to learned societies a certain number of copies of all the works which he may publish. By adopting this course, which has been warmly recommended by some of the principal ethnologists of this country, more

service can be done in the way of advancing knowledge with the small appropriation which could be devoted to this purpose than by publishing the manuscripts, as was first intended, as a part of the Smithsonian Miscellaneous Collections. In accordance with this view, the grammar of the Mutsun language, mentioned in the last report, has been presented to Mr. Shea, and has been published by him as one of his series, full credit being given to the Institution in the title page, and in a separate advertisement.

The Mutsun Indians inhabited the country northwest of Monterey, California, comprising a district, according to Mr. Taylor, of 170 miles long by 80 broad, and are the most northerly tribe known of whose language the Spanish missionaries compiled a grammar. Their village lay in the centre of a valley which abounded in rich land, and as late as 1831 numbered twelve hundred souls. For the purpose of comparison this work therefore possesses great value. The late W. W. Turner says that this language is clearly the same as the Rumsen or Rumsien, one of the two spoken at the mission of San Carlos, and at the mission of La Soledad, further to the south. It also bears a considerable degree of resemblance to the language of the Costanos on the bay of San Francisco, and also a fainter one to other languages further north. The grammar is printed in superior style, on excellent paper, by J. Munsell, of Albany, and forms Part IV of the linguistic series above mentioned, the following being the titles of the three previous parts, viz:

1. A French Onondaga dictionary, from a manuscript of the 17th century.
2. A Selish or Flathead grammar, by Rev. Gregory Mengarini.
3. A grammatical sketch of the Hèvè language, spoken in the middle of the last century in Sonora; translated from an unpublished manuscript by Buckingham Smith.

Besides the fourth number, the other works which have been placed in the hands of Mr. Shea for publication are the Mutsun vocabulary, the Yakama grammar, and the Sextapay vocabulary. The paper on the languages of the western coast mentioned in the last report as in preparation by Mr. George Gibbs is still in progress. He has received several valuable additions of materials for comparison of the different languages under investigation.

The publication in the last report of the general views on archæology, by Morlot, of Switzerland, has awakened a new interest in the remains of Indian art found in all parts of the United States, and

various collections are now being formed, which will be of great interest in comparing analogous stages of the mental development of the primitive inhabitants of this country and those of Europe. For the purpose of assisting this comparison it is proposed to make photographic impressions of all type specimens which have been found in this country, to be distributed to the most distinguished archæologists in Europe, and to invite a general exchange of illustrations and articles of this character. Mr. Franklin Peale, of Philadelphia, has arranged with artistic skill, in thirty tablets, nearly a thousand specimens of arrow heads, hatchets, knives, chisels, and other instruments belonging to the stone period, and has ascertained by actual experiment that a photographic picture can be taken of each tablet of full size, which presents the form and peculiarities of each article with such distinctness that the impressions may serve almost as well as the specimens themselves for comparative study.

Meteorology.—The system of meteorological observations, organized and carried on successfully for several years past, has suffered more from the disturbed condition of the country than any other part of the operations of the Smithsonian establishment. But few records have been received since the commencement of the war from Virginia, Kentucky, and Missouri, and, with two or three exceptions, none from the States further south.

The withdrawal of the troops from the numerous stations along the coast of the Pacific and from the interior of the continent has materially diminished the number of observers reporting to the office of the Surgeon General.

The popular system of daily telegraphic reports of the condition of the weather from distant parts of the United States has been discontinued; the continuity of the lines to the south having been interrupted, and the wires from the north and west being so entirely occupied by public business that no use of them could be obtained for scientific purposes.

We may mention in this connexion that a daily bulletin of telegrams relative to the weather in different parts of Europe, similar to that established by this Institution, is published at the Imperial Observatory at Paris, copies of which are regularly transmitted to us, through the kindness of the director, M. Le Verrier. From an examination of these records we find that the meteorological phenomena

of the temperate zone in the eastern hemisphere travel eastwardly, or in the same direction that they are observed to follow in the United States. The meteorologists, however, of London and Paris, are by no means as favorably situated for predicting the coming weather as those of Washington, New York, or Boston, since the storm which approaches the former comes from the ocean and admits of but very limited telegraphic announcement, while those which are coming toward the latter can be heralded over thousands of miles of wire.

We have continued to receive records of observations from the northern and western States, Canada, the Hudson's Bay Territory, Mexico, and Central America.

It was stated in the last report that on account of the suspension of the annual appropriation from the Patent Office for meteorological statistics the process of reduction had been discontinued, and we regret to say that we have not been able to resume this work during the past year. The reductions, however, prepared by Professor Coffin, under the direction and at the joint expense of the Smithsonian Institution and the Patent Office, for the years 1854–'59, inclusive, are still in the hands of the public printer. The work cannot be hurried through the press, since much labor and care are required for proper correction of the proof sheets ; the delay, however, has been mainly caused by the interruptions incidental to the entire change of system of Congressional printing, and the establishment of a government printing office. The work will form two large quarto volumes, the first of which is completed, with the exception of some introductory matter, and contains 1,270 pages. It exhibits the monthly and annual reductions for the barometer, thermometer, psychrometer, and rain guage, the observations on winds, clouds, &c.

The following statement from this volume of the number of observers for the several years, shows the growth of the system:

1854,	embraces	234	stations.
1855,	"	217	"
1856,	"	320	"
1857,	"	379	"
1858,	"	390	"
1859,	"	531	"

The second volume, which is also partly printed, will probably contain as many pages as the first, and will give the observations on

periodical phenomena, such as the appearance and disappearance of birds and animals, first and last frosts, dates of the opening and closing of rivers, lakes, harbors, &c.; also, detailed observations for the investigation of the principal storms of 1859; general tables of temperatures of several hundred places in North America, deduced from a series of years from all the reliable sources which could be commanded; also, a series of tables of rain at different places, deduced from observations for a series of years. The special object of the extended table of temperature is to furnish the materials for a more accurate isothermal map of the United States than has as yet been projected; and that of the rain tables, to present the data for a more reliable map of the average precipitation in the different parts of the country.

The volume will also contain special thermometric observations at stations distributed over the area extending from the Arctic regions to the northern States of South America, and from the Pacific to the Atlantic coast, for the purpose of showing the progress of cold periods across the continent, from the Rocky mountains to Bermuda. The same volume will also contain daily notices of the weather for the year 1859, gathered from published accounts, presenting items of information in a general and popular form, which may assist in the investigation of the movement of storms, and be of more interest to the general reader than the tabular statements of the principal part of the work.

The office work of the system of meteorology has continued in charge of William Q. Force, esq., of this city, to whom has also been intrusted the laborious duty of correcting the proof sheets of the volumes above mentioned.

Magnetic Observatory.—It was stated in the last report that as the changes in the direction and intensity of the magnetic force at Toronto were almost precisely the same as at Washington, it was concluded that more important service could be rendered to science by separating the points of observation to a greater distance. In accordance with this view, the instruments of the observatory on the Smithsonian grounds were sent to Key West, one of the Tortugas, where the United States has a military post, and the Coast Survey a tidal station. This location has been found well adapted to the purpose, and notwithstanding its proximity to the seat of active war, the photographic registration has been uninterruptedly kept up during the

past year, at the joint expense of the Coast Survey and the Smithsonian Institution.

Laboratory.—The operations of the laboratory during the past year have been principally confined to the examination and classification of the minerals which have been collected at the Institution from the various exploring expeditions, preparatory to a general distribution of the duplicates. This work has been intrusted to Mr. Thomas Egleston, of New York.

Facilities have been given to Professor Way, of London, for the exhibition of his improved method of producing an intense light for signals by means of the electrical deflagration of a stream of mercury, and the Institution is indebted to this gentleman for the present of a set of apparatus for exhibiting this light, and also of a powerful galvanic battery. The apparatus of the laboratory has been increased by a large Daniell's battery, consisting of fifty cylindrical copper cells, each six inches in diameter and fourteen inches high, with appropriate zinc elements of pure metal, procured expressly for the purpose from Mr. Wharton, of Pennsylvania.

Among the experiments which have been made, may be mentioned a series by Dr. Craig, on the effects of the explosion of gunpowder under pressure ; and another by the Secretary, on the burning of the same substance in a vacuum, and in different gases.

A series of researches was also commenced to determine more accurately than has yet been done the expansion produced in a bar of iron at the moment of magnetization of the metal by means of a galvanic current. The opportunity was taken, with the consent of Professor Bache, of making these experiments with the delicate instruments which had previously been employed in determining the varying length under different temperatures of the measuring apparatus of the base lines of the United States Coast Survey.

It may also be stated that the Secretary was requested by the War Department to report upon the practicability of employing balloons for military purposes, and in accordance with this request the several plans proposed by Mr. Lowe, of Philadelphia, and Mr. Helme, of Providence, were examined and practically illustrated on the Smithsonian grounds.

It may not be improper in this connexion to state that a considerable portion of the time of the Secretary, during almost every year since the beginning of the Institution, has been devoted to investiga-

tions pertaining to the operations of the general government. For these services no compensation has been asked or received.

It is believed that the Institution, through its Secretary and other officers, has been the instrument of important services to the government, which have repaid in some degree the fostering care which the latter has bestowed on the former.

Explorations.—For the purpose of obtaining a large number of duplicate specimens of the Zoology, Botany, and Mineralogy of North America, the Institution has not only furnished instructions and rendered assistance, in the way of making collections, to the various government expeditions undertaken during the last twelve years, but it has also engaged the services of persons of the requisite acquirements to make independent explorations. An account of these explorations has been given in the several reports for previous years, and it is therefore only necessary to mention at this time those which have been completed during the past year, or are still in progress.

The exploration in Lower California, near Cape St. Lucas, the southern extremity of the peninsula, by Mr. John Xantus, has been completed. The labors expended in this field have been truly remarkable. According to the statement of Professor Baird, Mr. Xantus has sent to the Institution sixty large boxes filled with specimens illustrating almost every branch of natural history. His explorations were not confined to the southern extremity of the peninsula, but extended many leagues up the coast on both the ocean and gulf sides. He also visited Mazatlan, on the Mexican coast, and made a valuable collection of birds. The specimens which he collected contain a large number of species never before described. These have been submitted for study and examination to some of the principal naturalists in this country and Europe. In closing the accounts of the explorations in Lower California it is necessary to acknowledge the services rendered to the natural history of this country by the Coast Survey, under the direction of Professor Bache, in affording Mr. Xantus, while discharging the duty of tidal observer, the opportunity of making these valuable collections at points which would otherwise be almost inaccessible to the naturalist.

The explorations by Mr. Robert Kennicott, in the northwestern part of this continent, are still going on, the Hudson's Bay Company having extended the time and afforded additional means for the prosecution of the work. From the latest advices from Mr. Kennicott,

he had reached Fort Yukon, on the Yukon river, a post in Russian America, and in a region almost entirely unknown, not only in regard to its natural history but also as to its geography. From this point he intended to continue his explorations to the mouth of Anderson river, on the coast of the Arctic ocean, and to return home about the end of the year 1863. It is proper to remark that in defraying the expense of this exploration the Institution has been assisted by the University of Michigan, the Chicago Audubon Club, the Chicago Academy of Natural Sciences, and by several gentlemen interested in natural history, and that without the facilities afforded by the Hudson's Bay Company and its officers the enterprise, as at present extended, could not have been accomplished. Not only has Mr. Kennicott been received as a guest at the different posts, but free transportation has been afforded for himself and his collections. It is gratifying to the friends of this zealous and accomplished young naturalist to learn that he has everywhere succeeded in exciting the sympathy and awakening the interest of the officers and employés of the foreign governments through whose territories his explorations have extended. And, thus, while actively engaged himself in extending our knowledge of these remote regions, he has diffused a taste for natural history, and enlisted the services of a number of active collaborators.

The officers of the Hudson's Bay Company have instituted local explorations at the principal stations, which, taken in connexion with what Mr. Kennicott is doing, bid fair to make the natural history of Western Arctic America as well known as that of any part of the continent. Among the most active of those who have become voluntary collaborators of the Institution is Mr. Bernard R. Ross, chief factor of the Mackenzie river district. From that gentleman we are receiving, from time to time, valuable collections of specimens to illustrate the natural history and ethnology of the region in which he resides.

Another gentleman, Mr. Lawrence Clark, jr., of Fort Rae, has contributed largely to our collection of specimens from the vicinity of Slave lake. Besides these, I must refer to the report of Professor Baird for the names of a number of other gentlemen who have made similar contributions from different parts of the Hudson's Bay territory, and other districts of North America.

Collections of Natural History, &c.—In the last report of the Institution, a distinction was made between the collections of natural his-

tory and the museum of the Institution; the object of the former being more essentially in accordance with the primary idea of the establishment, namely, the advance of science, and that of the latter a public exhibition of the natural history, principally of the North American continent, for popular as well as scientific study.

While it has not been contemplated to employ any large portion of the Smithsonian income in the support of a general museum, which, under the most favorable circumstances, must be, in a considerable degree, local in its influence, and can only produce its best effects when connected with an educational establishment, as in the case of the great museum now in process of being formed by Professor Agassiz at Cambridge, yet much labor and money have been expended in making the collections, with a view principally to obtain new materials for the investigation and illustration of the natural history, mineralogy, and geology of this country. As the primary object of the Institution is the advance of science, such a disposition of the specimens is sought to be made as will best secure this end.

The specimens may be divided into two classes—1st, those which have been described in the reports of government expeditions or the transactions of the Smithsonian and other Institutions; and 2d, those which have not been described, and which consequently are considered of much value by the naturalists who are interested in extending the several branches of natural history. Of both classes the Institution possesses a large number of duplicates, in the disposition of which some general principles should be kept constantly in view. After due consultation with naturalists, the following rules, which were presented in the last report, have been adopted relative to the *described* specimens:

First. To advance original science, the duplicate type specimens are to be distributed as widely as possible to scientific institutions in this country and abroad, in order that they may be used in identifying the species and genera which have been described.

Second. To promote education, as full sets as possible of general duplicates, properly labelled, are to be presented to colleges and other institutions of learning that profess to teach the principal branches of natural history.

Third. It must be distinctly understood that due credit is to be given to the Institution in the labelling of the specimens, and in all accounts which may be published of them, since such credit is not only

due to the name of Smithson, but also to the directors of the establishment, as vouchers to the world that they are faithfully carrying out the intention of the bequest.

Fourth. It may be proper, in the distribution to institutions abroad, as a general rule, to require, in case type specimens to illustrate species which have been described by foreign authors may be wanted for comparison or other uses in this country, that they be furnished at any time they may be required.

Fifth. In return for specimens which may be presented to colleges and other educational establishments, collections from localities in their vicinity, which may be desirable, shall be furnished when required.

In the disposition of the *undescribed* specimens of the collection, it is impossible to be governed by rules quite as definite as those which relate to the previous class, but the following considerations have been adopted as governing principles :

1. The original specimens ought not to be intrusted to inexperienced persons, or to those who have not given evidence of their ability properly to accomplish the task they have undertaken.

2. Preference should be given to those who are engaged in the laborious and difficult task of preparing complete monographs.

3. As it would be illiberal to restrict the use of the specimens, and confine the study of them to persons who can visit Washington, the investigator should be allowed to take them to his place of residence, and to retain them for a reasonable time.

4. The investigator must give assurance that he will prepare a set of type specimens for the Smithsonian museum, and will return all the duplicates, if required.

5. In any publication which may be made of the results of the investigation, full credit must be accorded to the Institution for the facilities which have been afforded.

At the last session of Congress an appropriation was made to assist in the general distribution of duplicate specimens, and this distribution has been carried on as efficiently as the laborious character of the work would allow. The mere distribution of the specimens among colleges and educational establishments in this country, without labels or descriptions, would be little better than scattering them to the winds; but to present them correctly named and described renders them important auxiliaries in the study of natural history, and indirectly in the advance of this branch of knowledge itself. But this

work requires a critical knowledge of each particular class of specimens, and consequently the co-operation of a number of experienced naturalists, each of acknowledged authority in his special department.

The assortment and labelling of the larger part of the shells is still in progress under Mr. Philip P. Carpenter, of Warrington, England, assisted by Dr. Alcock. Certain marine families have been sent to Professor Agassiz; a part of the fresh water shells has been named by Mr. Isaac Lea, of Philadelphia; another part by Mr. W. G. Binney, of New Jersey; another class of mollusks has been consigned to Mr. Busk, of England; and a third has been sent to Dr. Steenstrup, of Copenhagen.

The botanical collection is still in charge of Dr. Torrey, of New York, and Dr. Gray, of Cambridge.

The rocks and minerals have been partially labelled by Mr. Thomas Egleston, late a pupil of the School of Mines, Paris, who will probably finish the work during the present year.

The insects have been referred to Baron Osten Sacken, Dr. LeConte, Dr. Loew, Dr. Hagen, Dr. Morris, Dr. Clemens, Mr. Ulke, Mr. Uhler, and Mr. Edwards.

Certain classes of the mammalia have been examined by Dr. J. H. Slack and H. Allen, of Philadelphia; the birds by Mr. John Cassin, Mr. Elliott Coues, Dr. Bryant, and Mr. George N. Lawrence; the reptiles by Mr. E. D. Cope; the fishes by Mr. Alexander Agassiz, Mr. F. W. Putnam, Mr. Theodore Gill, and students of Professor Agassiz; the crustacea by Mr. Ordway and Mr. W. Stimpson; the radiata by Mr. Verrill and Mr. Stimpson; the fossils by Dr. Newberry, Mr. Meek, Dr. Hayden, and Dr. Gabb.

The whole of this part of the general business of the Institution has been, as heretofore, under the special charge of Professor Baird, to whose detailed report I would refer for a more particular account of these operations. From his report it will also be seen that the Institution has already distributed upwards of 80,000 specimens of natural history, and when it is recollected that each of these has been properly labelled and referred to printed lists, some idea of the amount of labor and time which has been expended on this work may be formed.

Type series of these specimens have been presented to the principal museums of Europe, and to the different societies for the promotion of natural history in this country. In every part, therefore,

of the civilized world, wherever natural history is cultivated, the name of the Institution has become familiar as a household word.

The distribution will be continued during the present year, provided no unforeseen event should occur to interrupt the operations now in progress.

Museum.—Considerable advance has been made during the year in improving the condition of the specimens for public exhibition in the museum. It is intended to label each article distinctly and accurately; but, although much labor has been expended on this work, it cannot be fully accomplished until all the specimens shall be thoroughly examined and properly described. A large number of additions has been made to the museum, and many imperfect specimens replaced by those of a better character.

During the past year Washington has been visited by a greater number of strangers than ever before since the commencement of its history. The museum has consequently been continually thronged with visitors, and has been a never-failing source of pleasure and instruction to the soldiers of the army of the United States quartered in this city or its vicinity. Encouragement has been given them to visit it as often as their duties would permit them to devote the time for this purpose.

Exchanges.—The system of exchanges has continued during the past year to be the principal means of communication between the scientific societies of the Old World and those of the New. As might have been expected, however, the number of copies of works sent abroad in 1861 was less than that of the previous year. The whole number of packages containing books, pamphlets, &c., sent abroad during the year was 1,099, containing, at least, 10,000 separate articles. The number of packages received in return, for societies in this country, exclusive of those for the Institution, was 1,406, which, on an average, would amount to upwards of 7,000 separate articles. During the same period there have been received by the Institution for its own library 2,886 books and other publications.

In return for the generous assistance the Institution has received in carrying on this system of exchange, it is proper to repeat what we have stated in previous reports, that the Cunard steamers between New York and Liverpool, the North German Lloyd between New York and Bremen, the Hudson's Bay Company, the Pacific Mail Steamship Company, and Panama Railroad Company, have carried

our packages free of cost on account of freight, and that the New York and Hamburg line has also generously rendered us a similar service. Adams' Express Company has transmitted our packages to and from different parts of the country at reduced rates. This appreciation of the objects of the Institution is as creditable to these companies as it is gratifying to the friends of the Institution.

Library.—Since the date of the last report the plan adopted in regard to the library has been steadily acted upon, namely: to obtain as perfect a series as possible of the transactions and proceedings of the learned societies which have existed, or now exist, in every part of the world. During the past year nearly 3,000 articles from societies abroad, and copies of nearly everything which has been published by societies in this country, in Canada, and South America, have been added to the list of scientific works previously in the library.

We have received no definite information since the date of the last report as to the progress which has been made, under the direction of the Royal Society, in the preparation of the classified index of all the papers contained in the transactions of learned societies, and in the scientific serials of different parts of the world. The work, however, is still going on, and will, without doubt, be completed as soon as so extensive an undertaking can be properly accomplished.

The second and concluding volume of the catalogue of zoological literature from 1750 to the present day, by J. Victor Carus, of Leipsic, which was mentioned in the last two reports, has been published; and we would again commend it to the patronage of naturalists as the best compilation which has yet appeared of the titles systematically arranged of isolated papers on zoology published in American as well as foreign journals.

Among the more important donations since the date of the last report are the following:

130 volumes from T. Einhorn, of Leipsic;
18 from the Institut de France;
27 from the Academy de Stanislas, Nancy;
13 from the Agronomical Society, of Poland;
21 from the Royal Swedish Society of Sciences;
11 from the Königlich Preussische Technische Bau-Deputation;
10 from Oberlausitzische Gesellschaft at Gorlitz;
30 from the University of Chile;
8 from the Imperial Printing Office, Vienna;

25 from the Royal Observatory, Greenwich;

33 from the Academy of Sciences, St. Petersburg;

and a valuable collection of works on natural history from one of the regents, General Joseph G. Totten, of the United States army.

Gallery of Art.—The Stanley collection of Indian portraits and scenes of Indian life, together with the Indian portraits received from the museum of the Patent Office, still continue to form an ethnological gallery of much interest to the numerous visitors of the Institution. The small appropriation which was previously made to repay Mr. Stanley for incidental expenses connected with this gallery has been continued during the past year. The application which Mr. Stanley has, for several years, made to Congress for the purchase of his gallery cannot be expected at this time to receive attention, although we hope that in a more favorable condition of the treasury an appropriation for the purpose will be granted.

The following are the additions which have been made to the collection of objects of art during the past year: A large marble bust of Pulaski on deposit; a colossal bust in plaster of Dr. Robert Hare. Another, of the same size, of Hon. George M. Dallas; also a bust of Thomas Jefferson, and another of Dr. E. K. Kane, all by purchase. They are original works of art, of considerable merit, by Henry D. Saunders.

Besides these, a series of busts in plaster, several valuable pieces of sculpture in marble, and a number of pictures, have been received from the museum at the Patent Office. Among the busts are the following: An excellent likeness of John Vaughan, for a long time librarian of the American Philosophical Society; one of Cuvier, the French naturalist; of Hon. Dixon H. Lewis, late member of Congress, remarkable for his immense bodily size; and of the Hon. Peter Force, of this city. Among the articles in marble are a full-sized medallion of Minerva from Pompeii, a half-size copy of the Apollo Belvidere, and two other half-size ancient statues, all of elaborate finish. Among the pictures is an original portrait of Washington by the elder Peale, painted immediately after the battle of Princeton. In addition to the foregoing, the collection has been increased by one hundred large engravings presented by Charles B. King, a well-known artist, who has resided many years in this city. These engravings are copies of celebrated pictures, and are illustrations of the style of some of the best masters of the art of engraving. They were to have been be-

queathed to the Institution, as Mr. King himself informed me, but he has lately concluded to present them before his death. A list of the engravings will be found in the appendix to the report of the present year, from which it will be seen that they form an interesting addition to the valuable collection of engravings already belonging to the Institution.

It was stated in the last report that, in accordance with the policy adopted by the Institution, it would be proper to co-operate with Mr. Corcoran in the liberal and generous enterprise he had undertaken of establishing a free gallery of art in the city of Washington, and to deposit in his collection the specimens which might belong to this establishment, due credit being given to the name of Smithson for all additions of this kind to the gallery in question. The condition of the country has, however, for the present interfered with the prosecution of the original design of Mr. Corcoran, and the large and elegant building which he has erected for carrying out his ideas is now occupied by the government as a depot for military stores.

Lectures.—On account of the uncertainty as to the amount of income of the Institution, and the distraction of the public mind in regard to the war, it has been thought advisable not to make any definite arrangements for the usual course of popular lectures during the season of 1861–'62. A few lecturers, however, have lately been engaged, and at least a partial course will be given.

As stated in previous reports, the lecture-room of the Institution is the most commodious apartment in the District of Columbia for public meetings, and frequent applications are made for its use for lectures and public assemblages not connected with the operations of the Institution. The use of the room has been freely allowed under the following conditions: First. That the object for which it was required should be of a benevolent character, or in some respects in accordance with the general operations of the establishment. Second. That subjects connected with sectarianism in religion, discussions in Congress, and partisan politics should be excluded. Third. That the actual expense of the gas and attendance should be defrayed by the parties who used the room.

The privileges granted with these restrictions, although, perhaps, of advantage to the city, have been found to be attended with unfavorable results to the Institution. At first the number of applicants was small, and principally confined to cases in which the

privilege could be granted without hesitation; the number has, however, been constantly increasing, and during the past half year there has scarcely been a day in which the favor has not been urgently solicited by some of those who flock to this city with plans and inventions by which, as it is asserted, the government and the public are to be greatly benefited. These applications are prompted not only by the consideration that the use of the room may be obtained without charge, but also by the desire to connect the name of the Institution with the schemes or doctrines with which the public are to be impressed.

Since the custom was first introduced of granting the use of the room for the purposes before mentioned, a large amount of valuable property has been accumulated in the building, which is especially exposed at night to injury and loss from fire and other causes. On this account, as well as that of the insulated and exposed position of the grounds, an extra corps of watchmen is required for the protection of the property every time the building is open at night for public purposes.

Again, it has been found a disagreeable matter to allow, even for benevolent purposes, a charge to be made by other parties for entrance to the building while, in accordance with the policy of the Institution, admittance is free to every one.

But the greatest difficulty which has been met with in regard to granting the use of the lecture room for other purposes than those of the Institution, is that of strictly enforcing the rules relative to the discussion of political and sectarian subjects, and the consequent impossibility of preventing the name of the Institution from being associated in the mind of the public with topics alike foreign to its peaceful character and its scientific reputation. It is in vain to disclaim the connexion of the Institution with the discussion of these subjects. The popular mind, particularly at a distance, cannot discriminate between the lectures given under the sanction of the Institution and those which are simply permitted to be delivered within its building.

In view of these facts it becomes a matter of grave deliberation whether or not the use of the lecture room ought to be granted for purposes not connected with the operations of the Institution; but, under existing circumstances, perhaps the subject had better be postponed for future consideration.

Respectfully submitted,

JOSEPH HENRY, *Secretary.*

APPENDIX TO THE REPORT OF THE SECRETARY.

Smithsonian Institution,
Washington, December 31, 1861.

Sir: I have the honor herewith to present a report for 1861 of the operations intrusted to my charge, namely: those which relate to the printing, the exchanges, and the collections of natural history.

Very respectfully, your obedient servant,

SPENCER F. BAIRD,
Assistant Secretary Smithsonian Institution.

Prof. Joseph Henry, L.L. D.,
Secretary Smithsonian Institution.

PRINTING.

The publications of the past year have consisted principally of works belonging to the octavo series of Smithsonian miscellaneous collections and reports, and they amount to about 1,400 pages.

EXCHANGES AND TRANSPORTATION.

As might have been expected, the operations in this department show a decrease in magnitude as compared with 1860. That year, however, was an exceptional one, and the receipts of 1861, though inferior to those of 1860, are yet equal to the average of preceding years. Many works of great value have been added to the library of the Institution, and numerous series of foreign transactions completed to date. The transmissions of books and pamphlets on behalf of American institutions has been very large, and the returns of corresponding magnitude.

It will be observed by the annexed table that the Smithsonian Institution is not only the medium of literary and scientific communication between the Old World and parties in the United States, but performs the same office for all the principal institutions in the remaining countries of America, as Canada, Cuba, Mexico, Chile, Brazil, New Granada, &c.

In 1861, as in previous years, very important services have been rendered by various transportation companies in the reduction or remission of freights. Among these may be mentioned from previous years the Pacific Mail Steamship Company, the Panama Railroad Company, the Cunard steamers, the Bremen or North German Lloyd, the Hudson's Bay Company, the Adams Express Company, &c. During the past year the directors of the New York and Hamburg

line have also authorized their agents to forward packages to or from the Institution free of charge.

The Institution is under many obligations to Mr. A. B. Forbes and Mr. Samuel Hubbard, of the Pacific Mail Steamship Company, in San Francisco, for important services in facilitating and conducting its general business of exchanges, shipments, &c., on the Pacific coast.

The domestic agents of exchange, consisting of Messrs. Swan, Brewer & Tileston, Boston; D. Appleton & Co., New York; J. B. Lippincott & Co., Philadelphia, and Robert Clarke & Co., Cincinnati, have, as heretofore, received and distributed without charge the copies of Smithsonian contributions to knowledge addressed to institutions within their reach.

A.

Receipt of books, &c., by exchange in 1861.

Volumes:		
Octavo		572
Quarto		196
Folio		53
		821
Parts of volumes and pamphlets:		
Octavo	1,255	
Quarto	583	
Folio	107	
		1,945
Maps and charts		120
Total		2,886

B.

Table showing the statistics of the foreign exchanges of the Smithsonian Institution in 1861.

Agent and country.	Number of addresses.	Number of packages.	Number of boxes.	Bulk of boxes in cubic feet.	Weight of boxes in pounds.
1. Dr. Felix Flügel, *Leipsic.*					
Sweden	13	26			
Norway	6	11			
Denmark	10	16			
Russia	29	46			
Holland	25	45			
Germany	232	342			
Switzerland	21	34			
Belgium	11	21			
	347	541	30	278	7,840

B.—*Table showing the statistics of the foreign exchanges, &c.*—Continued.

Agent and country.	Number of addresses.	Number of packages.	Number of boxes.	Bulk of boxes in cubic feet.	Weight of boxes in pounds.
2. HECTOR BOSSANGE & SONS, *Paris.*					
France	69	129			
Italy	39	64			
Spain	5	9			
Portugal	2	4			
	115	206	7	94	2,588
3. ROYAL SOCIETY, *London.*					
Great Britain and Ireland	151	205	6	73	2,030
4. *Rest of the world*	52	147	30	180	4,500
Total	665	1,099	73	625	16,958

N. B.—The total number of volumes in these 1,099 packages amounts to about 10,000.

C.

Addressed packages received by the Smithsonian Institution from parties in America for foreign distribution in 1861.

	Number of packages.
Albany, N. Y.—	
New York State Agricultural Society	10
Boston, Mass.—	
American Academy of Arts and Sciences	118
Boston Society of Natural History	64
Prof. Jules Marcou	20
Cambridge, Mass.—	
American Association for Advancement of Science	53
Prof. A. Gray	27
Chicago, Ill.—	
Lieut. Col. James D. Graham, U. S. A	907
Columbus, Ohio.—	
Ohio State Board of Agriculture	100
Leo Lesquereaux	50
Dorchester, Mass.—	
Dr. Ed. Jarvis	25

	Number of packages.
Indianapolis, Ind.—	
Institution for Deaf and Dumb	18
New Haven, Conn.—	
American Journal of Science	104
Prof. G. J. Brush	4
Little Rock, Ark.—	
State of Arkansas	800
New York.—	
New York Lyceum of Natural History	68
Astor Library	6
Charles B. Norton	500
Philadelphia, Pa.—	
Academy of Natural Sciences	173
American Philosophical Society	119
Entomological Society of Philadelphia	12
Princeton, N. J.—	
Prof. Arnold Guyot	12
Providence, R. I.—	
State of Rhode Island	6
St. Louis, Mo.—	
St. Louis Academy of Sciences	163
San Francisco, Cal.—	
California Academy of Natural Sciences	50
Toronto, Canada.—	
Canadian Institute	5
Washington, D. C.—	
U. S. Patent Office	20
U. S. Coast Survey	69
Secretary of War	120
Captain A. A. Humphreys	24
	3,627

D.

Addressed packages received by the Smithsonian Institution from Europe, for distribution in America, in 1861.

	Number of packages.
Albany, N. Y.	
Albany Institute	2
Dudley Observatory	3
New York State Agricultural Society	7
New York State Library	2
New York State Medical Society	1
Dr. Brunnow	1
Professor James Hall	8
Amherst, Mass.	
Amherst College	4
Annapolis, Md.	
State Library	2
Ann Arbor, Mich.	
Observatory	5
Professor Brunnow	1
Augusta, Me.	
State Library	2
Austin, Texas.	
State Library	2
Baltimore, Md.	
Maryland Historical Society	5
Snowdon Piggot	1
Baton Rouge, La.	
State Library	2
Bogota, New Granada.	
Sociedad de Naturalistas Neo Granadinos	3
Sociedad Economica de Amigos del Pais	1
Boston, Mass.	
American Academy of Arts and Sciences	63
American Statistical Association	7
American Unitarian Association	1
Boston Society of Natural History	54
Boston, Mass.—Continued.	
Bowditch Library	1
Geological Survey	2
Massachusetts Historical Society	2
New England Historic-Genealogical Society	1
Prison Discipline Society	1
Public Library	8
State Library	6
James Barnard	1
M. Girard	2
Edward Habich	1
Dr. E. Jarvis	3
Professor C. T. Jackson	2
Professor Jules Marcou	2
Professor Moreland and F. Minot	1
Professor W. B. Rogers	2
Geo. Ticknor	1
Brookline, Mass.	
Dr. Lyman	2
Brooklyn, N. Y.	
Dr. Louis Bauer	1
E. Nugent	1
Brunswick, Me.	
Bowdoin College	3
Historical Society of Maine	1
A. S. Packard	2
Burlington, Iowa.	
Iowa Historical and Geological Institute	1
Burlington, Vt.	
University of Vermont	4
Cambridge, Mass.	
American Association for Advancement of Science	14
Astronomical Journal	3
Astronomical Observatory	13
Harvard College	15
Nautical Almanac Office	1
Professor L. Agassiz	25

D.—*Addressed packages received by the Smithsonian Institution, &c.*—Continued.

	Number of packages.
Cambridge, Mass.—Continued.	
G. P. Bond	3
Professor Clark	1
Dr. B. A. Gould	10
Professor Asa Gray	11
Professor Pierce	5
F. W. Putnam	1
J. D. Runkle	1
Ernest Schubert	1
Mr. Sullivan	1
Dr. Tuckerman	1
A. E. Verrill	1
Professor J. E. Worcester	6
Charleston, S. C.	
Elliott Society of Natural History	14
Society Library	3
Dr. C. Happoldt	1
Professor J. E. Holbrook	1
Wilmot De Saussure	1
Charlottesville, Va.	
University of Virginia	4
Chicago, Ill.	
Academy of Chicago	1
Chicago Historical Society	1
Mechanics' Institute	4
Messrs. N. S. David and Byford	1
Colonel J. D. Graham	1
Cincinnati, Ohio.	
American Medical College	1
Historical and Philosophical Society of Ohio	2
Mercantile Library	4
Observatory	3
Professor Mitchell	1
Dr. Newton	1
Columbia, Penn.	
S. S. Haldeman	1
Columbia, S. C.	
South Carolina College	4
State Library	2
Columbus, Ohio.	
Ohio State Agricultural Society	25
State Library	3
Leo Lesquereux	1
Concord, N. H.	
New Hampshire Historical Society	4
State Library	2
Des Moines, Iowa.	
State Library	9
Detroit, Mich.	
Michigan State Agricultural Society	9
Messrs. Palmer, Gunn & Stearns	1
Dr. Zena Pitcher and A. B. Palmer	1
Dorchester, Mass.	
Dr. E. Jarvis	1
East Greenwich, N. Y.	
Asa Fitch	1
Frankfort, Ky.	
Geological Survey of Kentucky	5
State Library	2
Gambier, Ohio.	
Kenyon College	4
Georgetown, D. C.	
Georgetown College	8
Arthur Schott	2
Hanover, N. H.	
Dartmouth College	5
Professor Young	1
Harrisburg, Penn.	
State Library	4
Hartford, Conn.	
Historical Society of Connecticut	2
State Library	3
Young Men's Institute	3
Havana, Cuba.	
Meteorological Observatory	1

D.—*Addressed packages received by the Smithsonian Institution, &c.*—Continued.

	Number of packages.
Hudson, Ohio.	
Western Reserve College	5
Indianapolis, Ind.	
Indiana Historical Society	1
State Library	3
Iowa City, Iowa.	
State University	29
Jackson, Miss.	
State Library	2
Janesville, Wis.	
State Institution for the Blind	1
Jefferson City, Mo.	
State Library	2
Lansing, Mich.	
Michigan State Agricultural Society	4
State Library	3
Lecompton, Kansas.	
State Library	2
Little Rock, Ark.	
State of Arkansas	9
State Library	3
University of Arkansas	3
Louisville, Ky.	
Dr. Shotz	1
Professor J. L. Smith	1
Madison, Wis.	
Historical Society of Wisconsin	7
State Library	3
Wisconsin State Agricultural Society	17
McMinnville, Warren county, Tenn.	
C. F. Falconnet	1
Mexico, Mexico.	
Sociedad Mexicana de Geografia y Estadistica	2
Milledgeville, Ga.	
State Library	1
Montgomery, Ala.	
State Library	2
Montpelier, Vt.	
Historical and Antiquarian Society of Vermont	1
State Library	3
Montreal, C. E.	
Natural History Society	1
Professor T. S. Hunt	1
Sir W. E. Logan	1
Nashville, Tenn.	
State Library	3
Professor Blackie	1
New Brunswick, N. J.	
Professor George H. Cook	5
New Haven, Conn.	
American Journal of Science	24
American Oriental Society	10
Yale College	13
Professor J. D. Dana	24
Professor E. Loomis	6
Professor Silliman	15
Professor W. D. Whitney	5
New Orleans, La.	
New Orleans Academy of Natural Sciences	25
Dr. Bennet Dowler	1
New York, N. Y.	
American Ethnological Society	2
American Geographical and Statistical Society	38
American Institute	5
Astor Library	3
Board of Education	1
Historical Society	3
Mercantile Library Association	4
New York Journal of Pharmacy	1
New York Lyceum of Natural History	39
Norton's Literary Gazette	2

D.—Addressed packages received by the Smithsonian Institution, &c.—Continued.

	Number of packages.
New York, N. Y.—Continued.	
University Library	6
J. Russell Bradford	1
W. Dornbach	1
Dr. Daniel Eaton	2
David Dudley Field	1
Messrs. Frank & Norton	1
Henry Grinnell	5
M. Harlan	1
J. P. Humaston	1
Hon. William Marvin	1
Professor Redfield	1
Dr. E. Robinson	1
E. G. Squier	2
Dr. John Torrey	2
Olympia, Washington.	
Territorial Library	2
Omaha, Nebraska.	
Territorial Library	2
Philadelphia, Penn.	
Academy of Natural Sciences	77
American Philosophical Society	50
Central High School	1
Franklin Institute	1
Geological Survey	2
Historical Society of Pennsylvania	4
Philadelphia Library Company	3
Wagner Free Institute	5
W. G. Binney	1
Mr. Cope	1
H. S. Cranner	1
Dr. Robley Dunglison	1
Messrs. Gross & Richardson	1
Professor Haldeman	1
Isaac I. Hayes	1
Isaac Lea	8
Dr. John L. Leconte	2
Dr. Joseph Leidy	10
William Sharswood	5
Professor Wagner	1
Portland, Me.	
Neal Dow, Mayor of Portland	2
Princeton, N. J.	
College of New Jersey	1
Professor Alexander	1
Professor A. Guyot	2
Providence, R. I.	
Brown University	4
Rhode Island Historical Society	2
State Library	1
John Carter Brown	1
Quebec, C. E.	
Observatory	2
Quincy, Ill.	
Dr. John Ritter	1
Raleigh, N. C.	
State Library	2
Richmond, Va.	
Historical Society of Virginia	2
State Library	2
Rio Janeiro, Brazil.	
Inst. Hist. Geogr. of Brazil	3
Nautical Observatory	1
Rock Island, Ill.	
Benjamin D. Walsh	1
Sacramento, Cal.	
State Library	1
St. Augustine, Fla.	
Historical Society of Florida	1
St. John's, N. B.	
King's College	1
St. Louis, Mo.	
Geological Survey of Missouri, (Columbia, Mo)	5
St. Louis Academy of Sciences	56
University Library	4
Dr. George Bernays	1
Dr. George Engelmann	4
Messrs. Eginton & McPheeters	1
Dr. Adam Hammer	2
Mr. Leslie	1
Dr. S. Pollak	1
Dr. B. F. Shumard	3

D.—Addressed packages received by the Smithsonian Institution, &c.—Continued.

	Number of packages.		Number of packages.
St. Paul, Minn.		*Utica, N. Y.*	
Historical Society of St. Paul	1	American Journal of Insanity	4
State Library	1	*Valdivia, Chile.*	
Salem, Mass.		Dr. Eugen Von Boeck	1
Essex Institute	2	*Valparaiso, Chile.*	
Professor King	1	Dr. Thomas A Reid	2
Professor Russell	1	*Washington, D. C.*	
San Francisco, Cal.		Congress Library	6
California Academy of Natural Sciences	10	National Institute	2
Santiago, Chile.		National Observatory	45
Observatorio Nacional de Santiago	2	Ordnance Bureau	3
University Library	4	Secretary of War	2
Professor Lobeck	1	U. S. Boundary Commission	1
Dr. Moestas	2	U. S. Coast Survey	10
Savannah, Ga.		U. S. Patent Office	67
Georgia Historical Society	2	Colonel J. S. Abert	1
Springfield, Ill.		Professor A. D. Bache	25
State Library	2	W. P. Brown	1
Rev. Prof. Esbjörn	1	J. Ferguson	1
Rev. Fachtmann	1	Lieutenant Gilliss	6
Springfield, Mass.		Dr. Charles Girard	2
William Tully	1	Captain H. J. Hartstene	4
Toronto, C. W.		Professor W. E. Jillson	1
Canadian Institute	1	J. C. G. Kennedy	4
Magnetical and Meteorological Observatory	2	Lieutenant M. F. Maury	9
Trinity College	1	Baron Osten Sacken	1
Professor Kingston	1	George W. Riggs	3
Trenton, N. J.		M. A. L. Rives	1
Geological Survey of New Jersey	1	John A. Rockwell	1
State Library	2	H. R. Schoolcraft	8
		W. Stimpson	1
		Henry Ulke	1
		West Point, N. Y.	
		U. S. Military Academy	1
		Professor Bailey	1
		Major Bowman	1
		Worcester, Mass.	
		American Antiquarian Society	7

Total of addresses	274
Total of parcels	1,406

MUSEUM AND COLLECTIONS.

Additions.—The receipts of specimens during 1861, as might have been expected, were decidedly inferior to those of 1860, although much of great interest to science has been added to the collection since the date of the last report. Several explorations which had been planned were, of necessity, abandoned, owing to various impediments and difficulties. Among these may be mentioned an exploration of the region about Devil's river, Texas, by Patrick Duffy, hospital steward, United States army; of Fort Churchill, by Lieutenant John Feilner, United States army; and of Lake Winnepeg, by Donald Gunn. These, it is hoped, however, are only deferred to be hereafter resumed and carried out under better auspices.

No government expeditions have furnished any collections during 1861, excepting the Northwestern Boundary Commission, and their collections were all made in 1860, only arriving in 1861. All the rest were derived from resident correspondents of the Institution, or from gentlemen making explorations in the field in its behalf. A full list of all such receipts is given herewith, to which I would refer for particulars.

In addition to the operations of Mr. Xantus, Mr. Kennicott, and officers of the Hudson's Bay Company, mentioned specially hereafter, I may state that important contributions to our knowledge of the regions adjacent to the United States have been furnished by Mr. Charles Wright, from Cuba; Mr. W. Thomas March, of Jamaica, and Dr. Sartorius, of Mexico.

Very valuable collections of type specimens have been received from Dr. Hartlaub, of the Bremen museum; Drs. Reinhardt and Steenstrup, of the Copenhagen museum; Mr. P. L. Sclater, of London; the Messrs. Verreaux, of Paris; and Professor Agassiz, of the Cambridge museum.

The following are the explorations during the year from which the largest results have been received:

EXPLORATIONS.

Exploration of Cape St. Lucas and the Gulf of California, by Mr. John Xantus.—In the two last reports reference was made to that exploration following one of the region about Fort Tejon, California, by the same gentleman. I have now to report that the series of tidal and other observations made for the Coast Survey having been completed by Mr. Xantus, he has left Cape St. Lucas and returned to the east. The whole of the collections made by him have not yet arrived, but enough has been received during 1861, in continuation of previous years, to exhibit the ability and industry of Mr. Xantus as a naturalist. Over sixty boxes, some of large size, with contents embracing (and almost exhausting) every department of natural history, prepared and packed in a perfect manner, accompanied by numerous measurements, notes, and biographies, and all made in the intervals

of regular scientific duty, abundantly verify this estimate of Mr. Xantus's abilities.

In addition to the thorough exploration of the region immediately round Cape St. Lucas and the mountains in the vicinity, Mr. Xantus, since his residence there, has pushed his examinations many leagues up the coast, both on the ocean and gulf sides, and directly or indirectly extended them to a number of the islands, as Socorro, Tres Marias, &c. He also made a visit to Mazatlan during the past spring, and secured a valuable collection of birds.

The many new species collected by Mr. Xantus are in process of elaboration and will shortly be published. Partial reports have already been made on the birds by Mr. Xantus himself; on the reptiles by Mr. Cope; on the fishes by Mr. Gill; on the insects by Dr. Le Conte; on the crustacea and asteriadæ by Mr. Stimpson; on the ophiuridæ by Mr. Lyman; on the myriapoda by Mr. Wood; on the bats by Dr. Allen; on the plants by Dr. Gray, &c. The rich conchological materials are in the hands of Mr. P. P. Carpenter. It is proposed when all these examinations are completed to combine them in one general memoir, on the natural history of the cape, which will then be as well or even better known than the extremity of the corresponding peninsula of Florida, equally included in the limits of the North American fauna and flora.

Exploration of the Hudson's Bay territory by Mr. Kennicott.—At the date of the last advices from Mr. Kennicott, when the Smithsonian Report for 1860 was presented, he was at Fort Resolution, on Slave lake, where he had spent the preceding spring and summer, principally in collecting eggs of birds. He left Fort Resolution in August, 1860, and returned to Fort Simpson and proceeded immediately down the Mackenzie to Peels river. From Peels river he crossed the Rocky mountains to La Pierre's house, occupying four days in the transit, and arriving September 18th; left the next day for Fort Yukon, at the junction of Porcupine or Rat river and the Yukon or Pelly river, in about latitude 65° and longitude 146°. Fort Yukon, the terminus of his journey, was reached on the 28th of September, 1860.

The latest advices now on file from Mr. Kennicott were written January 2, 1861, up to which time he had made some interesting collections; but these, of course, were limited by the season. He had great expectations of success during the following spring, (of 1861,) which have no doubt been abundantly realized.

No collections were received from Mr. Kennicott in 1861, with the exception of a few specimens gathered in July and August, 1860, on Slave lake. Those made at the Yukon will, however, in all probability come to hand in October or November of 1862.

Mr. Kennicott expected to remain at the Yukon until August, 1861, then to start for La Pierre House and Fort Good Hope, possibly to Fort Simpson, to spend some months, and endeavor by early spring to reach Fort Anderson, near the mouth of Anderson river, (a stream between the Mackenzie and Coppermine rivers,) and in the barren grounds close to the Arctic ocean. At Fort Anderson he expected to

collect largely of the skins and eggs of birds, rare mammals, &c., and to return to Fort Simpson in the autumn, (of 1862,) then to arrive at Fort Chipewyan, on Lake Athabasca, by the spring of 1863, so as to get back to the United States by the winter of the same year.

For a notice of the continued aid to Mr. Kennicott, rendered by the gentlemen of the Hudson's Bay Company, I have to refer to the next division of my report.

Exploration of the Hudson's Bay territory by officers of the Hudson's Bay Company.—The gentlemen of many of the Hudson Bay Company's posts have largely extended their important contributions to science, referred to in the preceding report. A large proportion of the principal stations have thus furnished collections of specimens and meteorological observations of the highest value, which, taken in connexion with what Mr. Kennicott is doing, bid fair to make the Arctic natural history and physical geography of America as well known as that of the United States.

Pre-eminent among these valued collaborators of the Institution is Mr. Bernard R. Ross, chief factor of the Mackenzie River district, and resident at Fort Simpson. Reference was made in former reports to his contributions in previous years; those sent in 1861 are in no way behind the others, embracing numbers of skins of birds and mammals, some of great variety, insects, &c., besides very large series of specimens illustrating the manners and customs of the Esquimaux and various Indian tribes. Mr. Ross has also deposited some relics of Sir John Franklin, consisting of a gun used by him in his first expedition, and a sword belonging to the last one, and obtained from the Esquimaux. Mr. Ross is at present engaged in a series of investigations upon the tribes of the north, to be published whenever sufficiently complete, and illustrated by numerous photographic drawings.

In making up his transmissions to the Institution Mr. Ross has had the co-operation of nearly all the gentlemen resident at the different posts in his district, their contributions being of great value. Among them may be mentioned Mr. James Lockhart, Mr. William Hardisty, Mr. J. S. Onion, Mr. John Reed, Mr. N. Taylor, Mr. C. P. Gaudet, Mr. James Flett, Mr. A. McKenzie, Mr. A. Beaulieu, &c.

Second in magnitude only to those of Mr. Ross are the contributions of Mr. Lawrence Clarke, jr., of Fort Rae, on Slave lake, consisting of many mammals, nearly complete sets of the water fowl, and other birds of the north side of the lake, with the eggs of many of them, such as the black-throated diver, the trumpeter swan, &c.

Other contributions have been received from Mr. R. Campbell, of Athabasca; Mr. James McKenzie, of Moose Factory; Mr. Gladmon, of Rupert House; Mr. James Anderson, (a) of Mingan; Mr. George Barnston, of Lake Superior; and Mr. Connolly, of Rigolette. Mr. McKenzie furnished a large box of birds of Hudson's Bay, while from Mr. Barnston were received several collections of skins, and eggs of birds, new and rare mammals, insects, fish, &c., of Lake Superior.

It may be proper to state in this connexion that the labors of Mr.

Kennicott have been facilitated to the highest degree by the liberality of the Hudson's Bay Company, as exercised by the directors in London, the executive officers in Montreal, (especially Mr. Edward Hopkins,) and all the gentlemen of the company, in particular by Governor Mactavish, of Fort Garry, and Mr. Ross. In fact, without this aid the expense of Mr. Kennicott's exploration would be far beyond what the Institution could afford, even with the assistance received from others. Wherever the rules of the company would admit, no charge has been made for transportation of Mr. Kennicott and his supplies and collections, and he has been entertained as a guest wherever he has gone. No charge also was made on the collection sent from Moose Factory to London by the company's ship, and in every possible way this time-honored company has shown itself friendly and co-operative in the highest degree to the scientific objects of the Institution.

Northwest Boundary Survey, under Mr. Archibald Campbell.—This expedition has finally completed its labors in the field and returned to Washington, bringing rich results in physical science, as well as important collections in natural history. These, with what were previously sent hither from time to time, are in progress of elaboration, and reports are in preparation to be presented to Congress when completed.

It is with deep regret that I have to announce the death at sea, on his homeward voyage in February last, of Dr. C. B. Kennerly, the surgeon and naturalist of the Boundary Survey. Connected with this expedition from its beginning, in 1857, and, in conjunction with Mr. Gibbs, making the principal portion of its collections, his report on them would have been one of great value. For many years prior to 1857, however, he had been in intimate relations with the Institution as a collaborator, first while resident at his home, at White Post, Clark county, Virginia, then in 1853, as surgeon and naturalist to the Pacific Railroad Survey of Captain Whipple along the 35th parallel, then in the same relationship to the Mexican Boundary Survey, under Colonel Emory, in 1855. No one of the gentlemen who have labored so zealously to extend a knowledge of the natural history of the west within the last ten or twelve years has been more successful than Dr. Kennerly. Many new species have been first described by himself or from his collections, while his contributions to the biography of American animals have been of the highest interest.

IDENTIFICATION OF SPECIMENS.

The identification of the unnamed species in the Smithsonian collection has been carried on as rapidly as possible, with the co-operation of many naturalists of distinction. Some of it has been prosecuted within the building; most of it, however, by gentlemen who either came to Washington and made their selections or had specimens sent to them. The following persons may be specially mentioned in connexion with the several portions of the collection:

Mammals.—The monkeys and South American mammals generally have been studied by Dr. J. H. Slack, and the bats by Dr. H. Allen, both of Philadelphia. Several species not previously described have been found among them by these gentlemen.

Birds.—Mr. Cassin has continued his examinations of the South American birds. Mr. Elliot Coues has monographed the North American *Tringeæ*, or sandpipers; the *Laridæ*, or gulls; the *Colymbidæ*, or divers, and the *Aegiothi*, or pine finches. Several of these have already been published. Dr. Bryant has examined the *Guillemots* and large hawks, and Mr. Lawrence has identified the humming-birds.

Reptiles.—Mr. E. D. Cope has studied the exotic reptiles generally, and has had special reference to those from South America, Mexico, and the West Indies. Many new species have been described by him from the Smithsonian specimens. Professor Agassiz has not yet returned the Smithsonian collection of turtles.

Fishes.—Professor Agassiz has still in hand the Exploring Expedition fishes, a collection of nearly one thousand species. Mr. Alexander Agassiz has examined the Smithsonian *Embiotocoids*, or viviparous fishes of California. Mr. F. W. Putnam has completed the study of the *Etheostomoids*, and entered on that of the *Cottoids*. Several other important families have been sent to the Museum of Comparative Zoology, for investigation by students of Professor Agassiz. Mr. Gill has made particular study of the west coast fishes, and those collected at Cape St. Lucas by Mr. Xantus.

Crustacea.—Mr. Ordway has examined several groups of the crustacea, and others have been studied by Mr. Stimpson.

Radiates.—Mr. Stimpson has finished the study of the *Asteriades*, and Professor Agassiz has had in hand other of the star fishes. Mr. Verrill has made a detailed examination of all the corals.

Mollusks.—Mr. P. P. Carpenter has had in his hands for investigation, aided by Dr. Alcock, all the shells of the west coast of America, and many of the exotic collections. Certain marine families have been sent to Professor Agassiz. Mr. Isaac Lea has named all the *Unionidæ*. Mr. Binney has taken charge of the land and fresh-water *Univalves;* Mr. Bush has the *Polyzoa*. The *Cephalopods* have all been sent to Dr. Steenstrup, of Copenhagen, for a report.

Insects.—Dr. Le Conte and Mr. Ulke have examined the North American *Coleoptera;* Baron Osten Sacken and Dr. Loew the *Diptera;* Dr. Hagen the *Neuroptera;* Mr. Edwards and Drs. Morris and Clemens the *Lepidoptera*, and Mr. Uhler the *Hemiptera*.

Fossils.—Dr. Newberry has studied many of the fossil plants. Mr. Meek, aided by Dr. Hayden, has identified all the fossils collected by the latter gentleman. Dr. Gabb, of Philadelphia, has investigated a number of the tertiary and cretaceous shells.

Rocks and Minerals.—Mr. Thomas Egleston, jr., has been engaged

for several months in the determining and arranging of the minerals and rocks of the collection, aided in a portion of the labor relating to the latter work by Dr. Newberry and Mr. Gibbs.

Plants.—The plants have been in the hands of Drs. Torrey and Gray and Mr. Eaton, who are making much progress in the labor of selecting and labelling a complete series.

Results of many of the above investigations have already been published, others are nearly completed, while some will require a considerable time to complete. All, however, when presented to the world, are announced as being based upon the Smithsonian material, while the greater portion either have been or will be published by the Smithsonian Institution, as detailed in your report.

All the specimens thus submitted to examination are carefully labelled, and the duplicates set aside to be distributed as types to the institutions having strongest claims to them. As the work progresses the amount of material available for such distribution increases, and new collections are more readily used to a similar end.

The labor of cataloguing and registering the specimens has been continued as rapidly as other duties would allow, the result at the end of the year being stated in the annexed table. In this I have been much assisted by the gentlemen named above, as well as in addition by Mr. John M. Woodworth, Mr. W. Prentiss, Mr. R. B. Hitz, and Mr. Fitzgerald.

DISTRIBUTION OF SPECIMENS.

The distribution of specimens has been carried on very largely during the year. About fifty sets of duplicate shells of the United States Exploring Expedition have been sent to as many institutions, while large numbers of species in all classes of the animal kingdom have also been supplied. A rough estimate gives 40,000 species and 80,000 specimens of natural history as thus distributed up to date, while many more are nearly in readiness. When it is considered that all these have been named and labelled by naturalists admitted to be of the highest authority in their respective departments, and that all have thereby the character and value of types, many of them belonging to species first described from Smithsonian specimens, or serving as the materials of elaborate monographs, it will be readily understood how much their systematic and judicious distribution by the Institution all over the world must conduce to the advancement of science.

WORK DONE IN THE MUSEUM.

Good progress has been made during the year in the proper arrangement and labelling of the specimens in the museum hall. Many of the shelves have been edged with black strips, and many stands whitened and renewed. Additional cases have been erected at the east end of the hall for the accommodation of the large birds which crowded inconveniently those already filled. A number of floor cases have been constructed to receive the large collection of shells.

Much labor has been expended on the identification and labelling of the exotic birds, but this work is now nearly finished. When, in accordance with the plan, these, as well as all the other specimens in the hall, are accurately and legibly labelled, with both their scientific and vernacular names, the gratification of the public in examining the rich treasures of the museum will be greatly enhanced.

Table exhibiting the total number of entries on the record books of the Smithsonian collection at the end of each year from 1851 *to* 1861, *inclusive.*

	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.
Skeletons and skulls....	911	1,074	1,190	1,275	2,050	3,060	3,340	3,413	3,650	4,350	4,459
Mammals..............	......	114	198	351	1,200	2,046	3,200	3,226	3,750	4,575	5,550
Birds.	......	......	......	4,353	4,425	5,855	8,766	11,390	15,913	20,875	23,510
Reptiles..............	......	......	......	......	......	106	239	4,370	4,616	4,683	6,088
Fishes....	......	......	......	......	......	155	613	1,136	1,740	2,975	3,643
Eggs of birds	......	......	......	......	......	....	....	1,032	2,525	4,425	4,830
Crustacea.............	......	......	......	......	......	....	....	939	939	979	1,287
Mollusks....	......	......	......	......	......	....	....	....	2,000	8,832	9,718
Radiates	......	......	......	......	......	....	....	....	1,100	1,308	1,800
Fossils	......	......	......	......	......	....	....	....	171	705	1,031
Minerals..............	......	......	......	......	......	....	....	....	793	1,132	3,500
Ethnological specimens.	......	......	......	......	......	....	....	....	....	550	550
Annilids	......	......	......	......	......	....	....	....	....	....	109
Total.............	911	1,188	1,388	5,979	7,675	11,222	16,158	25,506	37,197	55,389	66,075

Entries during 1861, 10,686.

LIST OF DONATIONS TO THE MUSEUM IN 1861.

Akhurst, J.—Mammals from Bogota.
Allen, W. T.—Eggs of birds from Virginia.
Ambrose, Rev. J.—Skin of *Mergulus alle.*
Anderson, (*a*) *James.*—Wolf-fish from the Gulf of St. Lawrence.
Austin, J. B.—*Menobranchus*, from Chicago.
Backus, Miss Julia E.—Australian boomerang.
Baird, S. F.—Four boxes minerals and rocks, of Essex county, New York, and one bottle *Coregonus* of Lake Champlain.
Baird, W. M.—*Sigillaria*, from Schuylkill county, Pennsylvania.
Barnston, George.—Horns of caribou, skins of mammals and birds, skeletons, nests and eggs, insects, &c. Lake Superior.
Beadle, D. W.—Fishes from Canada West.
Beaulieu, A.—Skins of birds, &c., McKenzie river. (Through B. R. Ross.)
Bishop, F. A.—Soils and earths collected in Utah. (Through Department of Interior.)
Boardman, G. A.—Skins and eggs of birds of New Brunswick.
Boettner, Gustav A.—Insects, &c., of Kansas.
Boyle, P. F.—Chicken with four legs.
Brandt, Henry.—Mammals, birds and eggs of Kansas.
Bremen Museum.—Five mounted Arctic birds, and skull of European brown bear.
Brevoort, J. C.—Mammals from Central America.
Brewer, Dr. T. M.—Nest of eggs of *Helminthophaga ruficapilla.*

British Government.—Fragment of meteorite from India.
Bryant, Dr. H.—Skins and eggs of birds.
Buckner, Rev. H.—Bitumen from the Cherokee nation.
Burling, William.—Skin canoe or cayak, and skin dress of Indians of N. W. America, (through J. W. Raymond.)
Cambridge, Museum of Comparative Zoology.—Eight species embiotocoids of California, and seven of ophiurans.
Campbell, Archibald.—Collections of animals, plants, rocks, &c., made by Dr. C. B. Kennerly and Mr. George Gibbs, naturalists and geologists of the northwest boundary survey.
Campbell, R.—Skins of mammals from the Hudson's Bay Territory.
Canfield, Dr. C. S.—Shells of the coast of California.
Chambliss, S. O.—Crystallized quartz from North Carolina.
Clarke, jr., Lawrence.—Very large collections of mammals, birds, eggs, &c., of Slave lake.
Conradsen, R.—Eggs of *Fulix marila*, Iceland.
Cooper, Dr. J. G.—Birds' eggs from Rocky mountains.
Copenhagen, Royal Museum.—Skins of Arctic birds: Echinoderms, &c.
Couper, W.—Skins of ducks and of *Saxicola œnanthe* from Quebec.
Dawson, Professor J. W.—Pleistocene and Devonian fossils of Canada.
Dodd, P. W.—Skins and eggs of birds, &c., of Sable island.
Flett, Jas.—Birds, &c., from La Pierre House, H. B. T. (through B. R. Ross.)
Foreman, Dr. E.—Minerals, rocks, animal tracks, &c., from near Emmetsburg, Maryland.
Fuller, Mr.—Shells of the coast of Maine.
Gaudet, C. P.—Birds, &c., from Peel's river, H. B. T., (through B. R. Ross.)
Gibbs, George.—See *Archibald Campbell.*
Gilliss, Captain J. M.—Eight bottles alcoholic specimens from Atlantic ocean.
Gilpin, Dr. J. B.—Skins of mammals of Nova Scotia.
Gladmon, Mr.—Nests and eggs from Hudson's Bay.
Gould, C. L.—Sea birds in the flesh, and in skins, from the coast of Maine.
Gove, Captain.—Eggs of birds from Utah.
Greenwood, Mrs.—Specimens of algae from the coast of Massachusetts.
Greenwood, Thomas L.—Nests and eggs of birds.
Gruber, F.—Skins and eggs of birds of California.
Hardisty, W. L.—Mammals, birds, &c., from Fort Liard on the Yukon, (through B. R. Ross.)
Haymond, Dr. R.—Nest and eggs of *Mniotilta.*
Heerman, Dr. A. L.—Skins and eggs of North American birds.
Hewett, Dr. Thomas.—Two mounted ducks.
Hitz, R. B.—Nests and eggs of birds of Pennsylvania.
Holder, Dr. J. B.—Eggs of birds from the Tortugas.
Holt, Hon. Jos.—Chameleon, centipede, &c., from Jerusalem.
Kautz, Captain A. V.—Skins of salmon of Puget Sound.
Kellogg, F.—Eggs of birds from Texas.

Kennerly, *Dr. C. B. R.*—See *Archibald Campbell.*
Kennicott, *Robert.*—Zoological specimens, plants, &c., from Great Slave lake.
Kirtland, *Prof. J. P.*—Living *Nerodia erythrogaster*, or red bellied water snake, from Ohio.
Krider, *J.*—Mounted tanager, egg of *Nauclerus furcatus*, or swallow-tailed hawk, skins of birds.
Laszlo, *Ch.*—Nest, eggs, and bird of *Saurophagus derbyanus*, Mexico.
Lazar, *Count Coloman.*—Skins and eggs of birds of Hungary.
Lincoln, *E. D.*—Box of eggs from Massachusetts.
Lockhart, *James.*—Mammals, &c., from the Yukon, (through B. R. Ross.)
Loweree, *R. G.*—Reptiles from Gaudalaxara, Mexico.
MacFarlane, *R.*—Birds, &c., from Fort Good Hope, H. B. T., (through B. R. Ross.)
McKenzie, *A.*—Birds, mammals, &c., from Liard river, H. B. T., (through B. R. Ross.)
Major, *J. J.*—Reptiles from Gaudalaxara, Mexico.
March, *W. Thos.*—125 skins of birds of Jamaica.
Maximilian, *Prince of Wied.*—Skins of European mammals.
Mowry, *Lieut. Sylvester.*—Skeleton of camel died in California.
Newberry, *Dr. J. S.*—Mammals from Lake Superior.
Onion, *J. S.*—Plants from the Mackenzie river, (through B. R. Ross.)
Otis, *G. N.*—Specimens of *Helix pulchella.*
Page, *Capt. T. J.*—Fossil wood from Buenos Ayres, and specimens of the materia medica of Paraguay.
Parkinson, *D. F.*—Box of birds of North California.
Poey, *Prof. F.*—Types of new species of Cuban fishes.
Prentiss, *Wesley.*—Skins of birds.
Prince, *Miss S.*—Annelid from the coast of Maine.
Raymond, *J. W.*—See *Burling.*
Reid, *J.*—Skins of mammals and birds, &c., from Great Slave lake.
Repetti, *A.*—Fossil fishes from Monte Bolca.
Reynolds, *Henry.*—Minerals, shells, &c., of Maine.
Ross, *B. R.*—Very full collections of the animals, plants, eggs, ethnological curiosities, &c., of the Mackenzie's river region of Arctic America.
Ross, *Mrs. Christina.*—Insects, curiosities, &c., from Mackenzie's river, (through B. R. Ross.)
St. Charles College, *La.*—Reptiles, eggs, &c., of Louisiana.
Samuels, *E.*—Microscopic slides.
Sartorius, *Dr. C.*—Birds, mammals, reptiles, and insects, from near Vera Cruz.
Savage, *Dr. Thos. L.*—Reptiles of Mississippi.
Scott, *Mrs. Dr.*—*Hippocampus*, or sea-horse, from Rappahannock river.
Smith, *Mrs.*—Skin and nest of *Emipidonax acadicus.*
Smith, *Jas. E.*—Two serpents, *Rhinostoma.*
Smith, *Dr. N. H.*—Skin of Albino blackbird.
Starbuck, *Alex.*—Shells, &c., of Massachusetts.
Starkey, *J. S.*—Silver ores from Oregon.

Sternbergh, J. H.—Alcoholic specimens from Panama.
Stone, H.—Eggs of birds.
Taylor, A. S.—Insects, shells, &c., of coast of California.
Taylor, N.—Birds, &c., from Fort Norman, H. B. T., (through B. R. Ross.)
Vanderweyck, P. H.—Minerals from Manhattan island, N. Y.
Vuille, Wm.—Skins and eggs of birds, Siskyon county, California.
Ward, Prof.—Cast of skull of *Ursus spelaeus* from the Cavern of Iserlohn, Germany.
Willis, J. R.—Mounted ptarmigan from Newfoundland, and specimens of natural history of Nova Scotia.
Winston, W. G.—Skins and eggs of birds of Nova Scotia.
Wood, W. S.—Eggs of birds.
Worthen, Prof. A. H.—Tertiary fossils of Mississippi.
Wright, Chas.—Birds, shells, reptiles, &c., of Cuba.
Xantus, J.—Large collections of animals, plants, fossils, minerals, eggs of birds, &c., of Cape St. Lucas; and skins of birds, &c., from the Three Maria's islands and the vicinity of Mazatlan; skins and eggs of birds from the Farralone islands.

LIST OF SMITHSONIAN PUBLICATIONS DURING 1861.

Classification of the Coleoptera of North America. Prepared for the Smithsonian Institution by John L. Le Conte, M. D. 8vo. pp. 302, and 47 wood cuts. Pp. 1–208; published May, 1861; 209–278, March, 1862.

Synopsis of the described Neuroptera of North America, with a list of the South American species. Prepared for the Smithsonian Institution by Hermann Hagen. July, 1861. 8vo. pp. 368.

Extracts from the proceedings of the Board of Regents of the Smithsonian Institution in relation to the electro-magnetic telegraph. (Reprinted from proceedings of the Board of Regents for 1857.) 8vo. pp. 40.

Annual Report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures, and condition of the Institution for the year 1860. 1 volume, 8vo., pp. 448; seventy-two wood cuts.

LIST OF LECTURES.

The following lectures have been delivered during the months of January, February, March, and April, 1862:

Two lectures by Rev. H. W. Pierson, president of Cumberland College, Kentucky, on "The private life of Thomas Jefferson."

One lecture by Professor A. Ten Brook, late United States consul at Munich, on the celebrated religious exhibition in the Bavarian Highlands, called the "Drama of the Passion," the only relic of the kind which has reached us from the middle ages.

Four lectures by Dr. I. I. Hayes, of Philadelphia, on "Arctic Explorations," with an account of his recent expedition.

One lecture by Rev. J. C. Richmond, of Milwaukee, Wisconsin, on "The origin and Saxon strength of the English tongue."

One lecture by Rev. W. A. P. Martin, a missionary, on "China and the Chinese."

One lecture by Rev. A. Cleveland Coxe, of Baltimore, Maryland, on "Popular taste in art and literature."

Three lectures by Professor Fairman Rogers, of Philadelphia, on "The Glaciers."

Three lectures by Rev. Francis Vinton, of New York, on "The Gentleman," "The Philosophy of War," and "Italy and Dante."

LIST OF METEOROLOGICAL STATIONS AND OBSERVERS

OF THE

SMITHSONIAN INSTITUTION

FOR THE YEAR 1861.

BRITISH AMERICA.

Name of observer.	Station.	North latitude.	West longitude.	Height.	Instruments.*	No. of months received.
		° ′	° ′	*Feet.*		
Acadia College	Wolfville, Nova Scotia	45 06	64 25	95	A	9
Baker, J. C.	Stanbridge, Canada East	45 08	73 00	....	T	11
Clarke, Mrs. Lawrence, jr.	Fort Rae, Great Slave Lake	....	....	....	T	3
Craigie, Dr. W.	Hamilton, Canada West	43 15	79 57	....	B. T.	12
Delaney, Edward M. J.	Colonial Building, St. John's, Newfoundland.	47 35	52 40	170	B. T. R.	12
Gunn, Donald	Red River Settlement, Hudson's Bay Territory.	50 06	97 00	853	T. R	6
Hall, Archibald, M. D.	Montreal, Canada East	45 30	73 36	57	A	11
Hensley, Rev. J. M.	King's College, Windsor, Nova Scotia.	44 59	64 07	200	A	6
Magnetic Observatory	Toronto, Canada West	43 39	79 21	†108	A	12
Mackenzie, John	Moose Factory, Hudson's Bay Territory.	51 15	80 45	....	B. T. R.	12
Phillips, H	Niagara, Canada West	43 09	79 20	270	A	8
Rankin, Colin	Michipicoton, Canada West	47 50	85 05	....	T	10
Richards, Thomas	Kenogumissee, Hudson's Bay Territory.	49 50	84 00	1,000?	T	5
Ross, Bernard R.	Fort Simpson, Hudson's Bay Territory.	61 51	121 25	....	T	3
Royal Engineers	Meteorological Observatory, Halifax, Nova Scotia.	44 39	63 37	8	A	2
Smallwood, Dr. Charles	St. Martin, Isle Jesus, Canada E.	45 32	73 36	118	A	12

ALABAMA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Shackelford, Prof. Josephus	Moulton	Lawrence	34 37	87 25	643	A	4
Tutwiler, Henry	Havana	Greene	32 50	87 46	500	T. R.	2
Waller, Robert B	Greensboro'	Greene	32 40	87 34	350	A	4

* A signifies Barometer, Thermometer, Psychrometer, and Rain Gauge.
B signifies Barometer.
T signifies Thermometer.
P signifies Psychrometer.
R signifies Rain Gauge.
N signifies No instrument.
† Above Lake Ontario.

ARKANSAS.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Blackwell, W. H	Perryville	Perry	35 05	93 16		N	3
Graham, Paul	Bentonville	Benton	36 23	94 10	1,790	N	5
Howard, J. S	Mountain Home	Marion	36 30	92 30		N	3
Moore, Alex. P., M. D	Washington	Hempstead	33 39	93 45		T. P. R.	1
Smith, Dr. Nathan D	Washington	Hempstead	33 44	93 41		T. R.	4

CALIFORNIA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Ayres, W. O., M. D	San Francisco	San Francisco	37 48	122 27	130	A	12
Belcher, W. C	Marysville	Yuba	39 29	121 30	80	B. T. R.	4
Blakeslee, Rev. S. V	Folsom	Sacramento				T. R.	8
Boucher, Wesley K	Mokelumne Hill	Calaveras	38 18	120 28	1,502	N	3
Dunkum, Mrs. E. S	Honcut	Yuba	39 25	121 30		T. R.	12
Frambes, Prof. Oliver S	Santa Clara	Santa Clara	37 18	122 00	100	A	3
Logan, Thomas M., M. D	Sacramento	Sacramento	38 35	128 28	41	A	12
Whitlock, James H	Meadow Valley	Plumas	40 20	120 15	3,700	B. T. R.	11

CHEROKEE NATION.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Hitchcock, Isaac B.	Lee's Creek	Sequohyah				T	2

COLORADO.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Ellis, Dr. Wm. T	Mountain City	Arapahoe	39 35	105 40	8,000	T	10

DISTRICT OF COLUMBIA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
MacKee, Rev. C. B.	Georgetown	Washington	38 54	77 03		T. R.	12
Smithsonian Institution	Washington	Washington	38 53	77 01	60	A	12

CONNECTICUT.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Case, Jarvis	Canton	Hartford	42 00	73 00	700	T. R.	1
Harrison, Benjamin F.	Wallingford	New Haven	41 27	72 50	133	A	12
Hunt, Rev. Daniel	Pomfret	Windham	41 52	72 23	587	A	12
Johnston, Prof. John	Middletown	Middlesex	41 32	72 39	175	A	12
Rankin, James	Saybrook	Middlesex	41 18	72 20	10	T. R.	6
Rockwell, Charlotte	Colebrook	Litchfield	42 00	73 06		T	12
Yeomans, William H	Columbia	Tolland	41 40	72 42		T	12

DAKOTA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Norvell, Freeman	Greenwood		42 52	98 24	1,900	T. R.	5

FLORIDA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Allen, George D. } Ferguson, G. F. } Oltmanns, J. G. }	Magnetic Observatory, Key West.	Monroe	24 33	81 48	6	B. T. P.	12
Bailey, James B	Gainesville	Alachua	29 35	82 26	184	T. R.	2
Dennis, William C	Key West	Monroe	24 33	81 28	16	B. T. R.	5
Steele, Judge Augustus	Atsena Otie	Levy	29 08	83 04	17	B. T. R.	3
Whitner, Benjamin F	Tallahassee	Leon	30 24	84 17	70	T	4

GEORGIA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Blewitt, Rev. W	Baston	Thomas	31 00	84 00	....	T. R.	2
Camp, Benjamin F	Covington	Newton	33 40	84 00	763	N	4
Gibson, R. T	Savannah	Chatham	32 02	81 01	18	T. R.	4
McAfee, J. R., M. D	Dalton	Whitfield	34 50	85 00	775	B. T. R.	3
Pendleton, E. M., M. D	Sparta	Hancock	33 17	83 09	550	T. R.	4
Van Buren, Jarvis	Clarksville	Habersham	34 35	83 31	1,632	T. P.	4

ILLINOIS.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Aldrich, Verry	Tiskilwa	Bureau	41 15	89 66	550	N	12
Allison, Jesse	Bloomington	McLean	40 30	89 00	....	N	7
Armstrong, M. C. } Roe, James H }	Chicago	Cook	....	....	....	B. T.	5
Babcock, Andrew J.	Aurora	Kane	41 41	88 17	650	T. R.	2
Babcock, E	Riley	McHenry	42 11	88 20	760	T. R.	12
Bacon, E. E	Willow Creek	Lee	41 45	88 56	1,040	T	7
Ballou, N. E., M. D.	Sandwich	De Kalb	41 31	88 30	575	T. R	12
Bandelier, Adolphus F., jr.	Highland	Madison	38 45	89 46	....	B. T	11
Bassett, George R	Woodstock	McHenry	42 18	88 30	....	T. R	3
Boettner, Gustav A	Chicago	Cook	41 54	89 40	....	B. T	4
Bowman, Dr. E. H	Edgington	Rock Island	41 25	90 46	686	T. R	6
Breed, M. A	Peoria	Peoria	40 38	89 46	512	T. R	12
Brendel, Frederick, M. D.	Peoria	Peoria	40 43	89 30	460	A	12
Brookes, Samuel	Chicago	Cook	42 00	87 30	....	T	12
Cobleigh, Rev. Nels. E., D. D	Lebanon	St. Clair	38 37	89 56	500	B. T. R.	12
Collier, Prof. Geo. H.	Wheaton	Du Page	41 49	88 06	682	A	8
Crandon, Frank	Batavia	Kane	41 52	88 20	636	T.	1
Dudley, Timothy	Jacksonville	Morgan	39 30	90 06	....	T. R.	12
Fitch, Dr. Joseph	Channahon	Will	41 15	88 16	....	B. T.	4
Grant, John	Manchester	Scott	39 33	90 34	683	A.	12
Harris, J. O., M. D.	Ottawa	La Salle	41 20	88 47	500	T. R.	12
Little, J. Thomas	Dixon	Lee	41 45	89 31	....	N	12
Livingston, Prof. Wm	Galesburg	Knox	....	....	....	A	11
Mead, S. B., M. D.	Augusta	Hancock	40 10	91 00	*203	T. P. R.	12
Mead, Dr. Thompson	Batavia	Kane	41 52	88 20	636	A	2
Meeker, Ralph E	Dongola	Union	37 26	89 21	....	T.	9
Newcomb, John B	Elgin	Kane	42 00	88 15	777	A.	3
Olds, Warren	Albany	Whiteside	41 40	90 16	600	N	12
Pashley, J. S., M. D.	Osceola	Stark	41 16	90 17	....	T. R.	5
Patrick, Dr. John J.	Bellville	St. Clair	38 29	90 06	600	B. T.	6
Riblet, J. H	Pekin	Tazewell	40 36	89 45	....	T. R.	12
Rogers, O. P. and J. S.	Marengo	McHenry	42 14	88 38	842	B. T. R.	12
Tolman, James W	Winnebago Depot.	Winnebago	42 17	89 12	900	B. T. R.	12
Trible, Mrs. Anna C	Upper Alton	Madison	39 00	89 36	....	A	2

* Above low water mark at Quincy.

INDIANA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Anderson, H. H	Rockville	Parke	36 00	87 00	1,100	N.	1
Austin, W. W	Richmond	Wayne	39 47	84 47	800	T.	5
Bartlett, Isaac	Logansport	Cass	40 45	86 13	600	T. R.	6
Bullock, J. T	Shelbyville	Shelby	39 00	87 00	....	N.	8
Chappellsmith, John	New Harmony	Posey	38 08	87 50	320	A.	12
Dawson, William	Cadiz	Henry	39 55	85 20	1,060	T. R.	12
Dayton, James H.	South Bend	St. Joseph	41 39	86 07	600	N.	12
Haines, John	Richmond	Wayne	39 52	84 59	....	B. T.	12
Larrabee, William H	Green Castle	Putnam	39 30	86 47	800	N.	7
Smith, Hamilton, jr.	Cannelton	Perry	37 57	86 42	450	A.	12
Spratt, W. W., M. D	Leo	Allen	....	....	....	T.	1
Webb, Miss Georgiana	Fort Wayne	Allen	41 10	85 00	761	N.	3

IOWA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instrument.	No. of months received.
			° ′	° ′	*Feet.*		
Beal, Dexter	Grove Hill	Bremer	42 45	87 15	....	T.	12
Beal, Willard W.							
Belfield, H. H.							
Chamberlain, John	Davenport	Scott	41 30	90 40	737	A.	12
Dunwoody, Wm. P.							
Boyle, C. R.	Washington	Washington	42 30	91 55	987	T.	2
Collin, Prof. Alonzo	Mount Vernon	Linn	42 00	91 00	....	T.	12
Deering, D. S.	Independence	Buchanan	....	....	....	T.	1
Doyle, L. H.	Waterloo	Black Hawk	42 30	92 31	....	N.	12
Foster, Suel	Muscatine	Muscatine	41 26	92 00	....	N.	12
Gidley, Isaac M.	Bangor	Marshall	42 00	93 00	....	T. R.	2
Horr, Asa, M. D.	Dubuque	Dubuque	42 30	90 52	666	A.	12
Hudson, A. T., M. D.	Lyons	Clinton	41 50	90 10	401	T. R.	12
Langer, Dr. Ignatius	Davenport	Scott	41 31	90 42	555	A.	3
McConnel, Townsend	Pleasant Plain	Jefferson	41 07	94 54	950	T. R.	12
McCoy, Franklin, M. D.	Algona	Kossuth	43 01	94 04	1,500	T.	12
McCoy, Miss Elizabeth							
McCready, Daniel	Fort Madison	Lee	40 37	91 28	....	T. R.	12
Marshall, Gregory	Vernon Springs	Howard	43 20	92 12	....	B. T.	6
Millard, A. J.	Sioux City	Woodbury	42 33	96 27	1,258	T. R.	10
Parvin, Theodore S.	Iowa City	Johnson	....	....	....	A.	12
Reid, Isaiah	Kossuth	Des Moines	41 00	91 13	....	N.	5
Sheldon, Daniel	Forestville	Delaware	42 40	91 50	....	T.	12
Ufford, Rev. John	Muscatine	Muscatine	41 25	92 02	586	A.	12
Williams, H. B.	Hesper	Winneshiek	43 30	91 46	720	T.	3

KANSAS.

Blackman, W. J. R.	Lawrence	Douglas	39 00	95 12	800	A.	10
Fish, Lucian	Burlingame	Shawnee	....	....	....	T. R.	3
Goodnow, Isaac T.	Manhattan	Riley	39 13	96 45	1,000	T. R.	12
Goss, B. F.	Neosho Falls	Woodson	38 03	95 31	....	T. R.	9
McCormick, Wm. A.	Lecompton	Douglas	39 03	95 10	825	T.	3
Scott, James	Gardner	Johnson	....	....	....	T.	8
Shaw, M.	Leavenworth	Leavenworth	39 18	94 32	896	T.	12

KENTUCKY.

Barbage, Joshua C.	Hardinsburg	Breckenridge	37 40	86 15	500	N.	8
Beatty, O.	Danville	Boyle	37 40	84 30	900	B. T. R.	11
Mathews, Jos. McD., D. D.	Nicholasville	Jessamine	37 58	84 18	940	A.	12
Mattison, Andrew	Paducah	Mt. Cracken	37 00	87 21	....	N.	12
Miles, Thomas H., S. J.	Bardstown	Nelson	37 52	85 18	....	A.	9
Savage, Rev. G. S., M. D.	Millersburg	Bourbon	38 40	84 27	804	B. T. R.	12
Swain, John, M. D.	Ballardsville	Oldham	38 36	85 30	461	A.	12
Williams, Prof. M. G.	Newport	Campbell	39 04	83 24	812	B. T. R.	5
Woodruff, E. N.	Louisville	Jefferson	38 20	85 38	....	A.	10
Young, Mrs. Lawrence	Louisville	Jefferson	38 07	85 24	570	A.	12

LOUISIANA.

Harrison, Thompson	New Orleans	Orleans	29 58	90 00	25	A.	2
Taylor, Lewes B.	New Orleans	Orleans	29 58	90 07	....	T. R.	2

MAINE.

Adams, John W.	Portland	Cumberland	43 39	70 00	180	N.	10
Brackett, G. Emerson	Belfast	Waldo	44 23	69 08	....	T. R.	12
Dana, Wm. D.	North Perry	Washington	45 00	67 06	100	A.	12

MAINE—Continued.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Gaines, Rev. A. G.	Bethel	Oxford	44 20	70 52	650	T. R.	12
Gardiner, R. H.	Gardiner	Kennebec	44 40	69 46	90	B. T. R.	12
Gould, M.	N'th Bridgeton	Cumberland	44 03	70 45	300	B. T. R.	12
Guptill, G. W.	Cornishville	York	43 40	70 44	800	T. R.	12
Johnson, Warren	Topsham	Sagadahoc	44 00	70 00	100	B. T.	8
Lord, W. G.	Limington	York	43 40	70 45	500	N.	2
Moore, Asa P.	Lisbon	Androscoggin	44 00	70 04	130	T. R.	12
Parker, J. D.	Steuben	Washington	44 44	67 50	50	A.	12
Pratt, J. Frank, M. D.	New Sharon	Franklin	44 37	70 03	......	N.	6
Reynolds, Henry	East Wilton	Franklin	44 44	70 17	......	N.	9
Van Blarcom, James	Vassalboro'	Kennebec	44 28	69 47	......	B. T.	9
Verrill, G. Washington, jr.	Norway	Oxford	44 10	70 35	......	T.	1
West, Silas	Cornish	York	43 40	70 44	784	T. R.	12
Wilbur, Benj. F.	Dexter	Penobscot	44 55	69 32	700	R.	12
Wilson, Dr. J. B.	Exeter	Penobscot	44 58	68 59	......	T. R.	8

MARYLAND.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Baer, Miss Harriott M.	Sykesville	Carroll	39 23	76 57	700	T. R.	12
Bell, Jacob E.	Leitersburg	Washington	39 35	77 30	......	T. R.	12
Dutton, Prof. J. Russel	Chestertown	Kent	39 12	75 59	......	A.	12
Goodman, Wm. R.	Annapolis	Anne Arundel	38 59	76 29	20	A.	12
Hanshew, Henry E.	Frederick	Frederick	39 24	77 26	......	A.	12
Johns, Montg., M. D.	Agric'l College	Prince George	......	......	......	A.	12
Lowndes, Benj. O.	Bladensburg	Prince George	38 57	76 58	70	T. R.	12
Stephenson, Rev. Jas.	St. Inigoes	St. Mary's	38 10	76 41	45	A.	12

MASSACHUSETTS.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Astronomical Observatory	Williamstown	Berkshire	42 43	73 13	725	B. T. R.	12
Bacon, William	Richmond	Berkshire	42 23	73 20	1,190	T. R.	12
Brown, Nathan W.	Topsfield	Essex	......	......	......	T. R.	12
Davis, Rev. Emerson	Westfield	Hampden	42 06	72 48	180	A.	12
Fallon, John	Lawrence	Essex	42 42	71 11	133	A.	12
Metcalf, John G., M. D.	Mendon	Worcester	42 06	71 34	......	T. R.	12
Mitchell, Hon. Wm.	Nantucket	Nantucket	41 17	70 06	30	A.	3
Morse, Geo. M., M. D.	Clinton	Worcester	42 25	71 42	......	T. R.	3
Normal School	Bridgewater	Plymouth	42 00	71 00	150	A.	4
Prentiss, Dr. Henry C.	Worcester	Worcester	42 16	71 48	528	A.	12
Raymond, George	Fitchburg	Worcester	42 35	71 50	484	P. T. R.	12
Reynolds, Orrin A.	Randolph	Norfolk	42 10	71 00	311	N.	2
Rodman, Samuel	New Bedford	Bristol	41 39	70 56	90	A.	12
Scandlin, Rev. Wm. G.	Grafton	Worcester	......	......	......	B. T.	6
Snell, Prof. E. S.	Amherst	Hampshire	42 22	72 34	267	A.	12
Terry, Charles C.	Fall River	Bristol	......	......	......	T.	3
Whitcomb, L. F.	Florida	Berkshire	42 41	73 02	2,000	F.	2

MICHIGAN.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Blaker, Dr. G. H., jr.	Marquette	Marquette	46 32	87 41	630	A.	12
Bowlsby, George W.	Monroe	Monroe	41 56	83 30	584	B. T. R.	1
Coffin, Matthew	Otsego	Allegan	42 28	85 42	662	N.	11
Crosby, J. B.	New Buffalo	Berrien	41 45	86 46	661	B. T. R.	7
Pitcher, Dr. Zena	Detroit	Wayne	42 24	82 58	597	A.	10
Smith, Charles C., M. D.	Redford Centre	Wayne	42 28	83 10	650	T. R.	3
Smith, Rev. L. M. S.	Mill Point	Ottawa	43 06	86 11	......	T.	12
Streng, L. H.	Holland	Ottawa	42 00	86 00	......	T. R.	12
Strong, Edwin A.	Grand Rapids	Kent	43 00	86 00	752	T. R.	4
Walker, Mrs. Octavia C.	Cooper	Kalamazoo	42 40	85 30	690	T. R.	12
Whelpley, Miss Helen I. } Whelpley, Miss Florence }	Monroe	Monroe	41 56	83 23	590	T. R.	12
Woodard, C. S.	Ypsilanti	Washtenaw	42 15	83 47	751	A.	12

MINNESOTA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Garrison, O. E.	St. Cloud	Stearns	45 45	94 23			10
Kelley, O. H.	Itasca	Anoka	45 16	93 32	856	T.	7
Riggs, Rev. S. R.	Pajutazee	Brown	45 00	94 00		T. R.	11
Smith, A. C.	Forest City	Meeker	45 45	96 00		T. R.	12
Thickstun, T. F.	Chatfield	Fillmore			*325	T. R.	5
	Hastings	Dakotah				B. T.	7
Wieland, C.	Beaver Bay	Lake	47 12	91 18	850	B. T.	12

MISSISSIPPI.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Cribbs, J. R.	Monticello	Lawrence	31 34	90 00	600	T.	2
McCary, Robert	Natchez	Adams	31 34	91 25	264	B. T. R.	6
Robinson, Rev. E. S.	Prairie Line	Jasper	32 10	89 20		A.	2
Swasey, Col. C. B.	Yazoo City	Yazoo	32 55	90 31		N.	3

MISSOURI.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bailey, S. S.	Dundee	Franklin	38 30	91 10	536	T. R.	6
Bowles, S. B., M. D.	Greenfield	Dade	37 22	93 41	1,800	N.	6
Christian, John	Harrisonville	Cass				N.	12
Engelmann, George, M. D.	St. Louis	St. Louis	38 37	90 15	481	A.	12
Fendler, Augustus	St. Louis	St. Louis	38 37	90 16	470	B. T. P.	12
Hanan, B. P.	Luray	Clark	40 28	91 57		N.	2
Horner, W. H.	Hornersville	Dunklin	36 03	90 00		T.	3
Koning, Rev. P. W.	St. Louis	St. Louis	38 40	90 15	475	A.	12
Maxey, W. F.	Paris	Monroe	39 30	92 00	700	T. R.	11
Myers, J. H.	Kirksville	Adair	40 38	92 50	1,000	N.	8
Ray, George P.	Canton	Lewis				T.	4
Sutherland, Norris	Boonville	Cooper	38 55	92 30		N.	5
Tidswell, Miss Mary Alice.	Warrenton	Warren	38 37	91 16	825	T.	12
Vankirk, W. J.	Bolivar	Polk	37 29	92 45		N.	1
Wells, William	Stockton	Cedar	39 36	93 48	800	T. R.	1
Wilson, Posey S.	Lexington	Lafayette	39 30	93 45		N.	4
Wyrick, M. L.	Cassville	Barry	36 41	93 57	3,000	T. R.	6

NEBRASKA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Allan, James P.	Omaha City	Douglas	41 15	96 10	1,300	T. R.	2
Bowen, Miss Anna M. J.	Elkhorn City	Douglas	41 22	96 12	1,000	T.	12
Child, A. L.	Glendale	Cass	41 15	96 00		T.	3
Evans, John	Fontenelle	Dodge	41 31	96 45	1,000	T.	12
Hamilton, Rev. Wm.	Bellevue	Sarpy	41 08	95 50		T. R.	12
Pardee, H. C.	Rock Bluffs	Cass	40 54	95 54	1,000	T.	2
Rosseau, M. C.	Fort Pierre†		44 00	100 00		N.	5
White, Bela	Kenosha	Cass	40 51	95 54	1,050	N.	12

NEW HAMPSHIRE.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Bell, Louis	Farmington	Strafford	43 20	71 00	300	B. T. R.	1
Bell, Samuel N.	Manchester	Hillsborough	42 59	71 28	300	B. T. R.	4
Brown, Branch	Stratford	Coos	44 08	71 34	1,000	T. R.	12
Chase, Arthur	Claremont	Sullivan	43 22	72 21	539	B. T. R.	12
Nason, Rev. Elias	Exeter	Rockingham	42 58	70 55	125	B. T.	12
Odell, Fletcher	Shelburne	Coos	44 23	71 06	700	B. T.	12
Pitman, Charles H.	North Barnstead	Belknap	43 38	71 27		T.	12

* Above La Crosse.

† Place of observation mouth of Cherry creek, Cheyene river; same in 1860.

NEW JERSEY.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	Feet.		
Harper, Prof. L.	Riceville	Monmouth	40 24	73 59	111	B. T. P.	8
Rhees, Morgan J., M. D.	Mount Holly	Burlington			30	B. T.	12
Stokes, Howard A.	Long Branch	Monmouth	40 20	74 06	10	T. R	2
Thompson, George W.	New Brunswick	Middlesex	40 30	75 31	90	N.	12
Thornton, Dr. S. C.	Moorestown	Burlington	39 58	74 57		T.	3
Whitehead, W. A.	Newark	Essex	40 45	74 10	35	B. T. R.	12
Willis, O. R.	Freehold	Monmouth	40 15	74 21		T.	12

NEW YORK.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Arden, Thomas B	Garrison's	Putnam	41 23	74 02	180	T. R.	12
Auber, John; Monroe, Prof. A. T.	Fordham	Westchester	40 54	73 57	147	B. T.	5
Bartlett, E. B.	Vermillion	Oswego	43 26	77 26	327	T.	12
Beauchamp, Wm. M.	Skaneateles	Onondaga	43 00	76 30	932	B. T.	12
Bowman, John	Baldwinsville	Onondaga	43 04	76 41		T.	12
Brown, Rev. John J.	Dansville	Livingston	42 38	77 54	672	A.	5
Clark, Sereno	Constantia	Oswego	43 17	76 05	424	T. R	1
Cowing, Philo	Seneca Falls	Seneca	42 54	76 51	463	B. T	8
Dill, John B	Auburn	Cayuga	42 55	74 28		T.	12
Denning, William H.	Fishkill Landing	Dutchess	41 34	74 18	42	B. T. R.	12
Dewey, Prof. Chester; Kreyer, C. T.	Rochester	Monroe	43 08	77 51	516	B. T. R.	12
Flint. Prof. Weston.	Otto	Cattaraugus	42 22	79 00	1,300	T.	2
Gregory, S. O.	Theresa	Jefferson	44 12	75 48	365	T. R	10
Guest, W. E.	Ogdensburg	St. Lawrence	44 43	75 37	232	R.	1
Haskin, Wm. L.	Troy	Rensselear	42 44	73 37	58	A.	6
Heimstreet, John W	Troy	Rensselear	42 44	73 37	58	A.	12
Hibberd, A. A	Hermitage	Wyoming	42 09	78 14		T. R	12
Holmes, Dr. E. S.	Wilson	Niagara	43 20	78 56	250	T.	12
House, John C.	Waterford	Saratoga	42 47	73 39	70	A.	12
Howell, Robert	Nichols	Tioga	42 00	76 32		T.	12
Ives, William	Buffalo	Erie	42 50	78 56	600	A.	12
Lattimore, Prof. S. A.	Lima	Livingston	42 53	77 51		B. T. P.	2
Mackie, Matthew	Clyde	Wayne	43 10	77 10	400	B. T.	12
Malcom, Wm. S.	Oswego	Oswego	43 28	76 30	250	B. T. R.	12
Mathews, M. M., M. D.	Rochester	Monroe	43 08	77 51	525	A.	12
Morris, Prof. O. W.	New York	New York	40 43	74 05	25	A.	12
Packard, Levi S	Spencertown	Columbia	42 18	73 32	700	A.	6
Potter, C. D., M. D.	Adams Centre.	Jefferson	43 48	75 52	632	R.	3
Russell, C. H.	Gouverneur	St. Lawrence	44 19	75 29		B. T	12
Slade, Fred. J.	New York	New York	40 45	73 59	79	A.	5
Spooner, Dr. Stillman	Wampsville	Madison	43 04	75 50	500	T. R	12
Sylvester, Dr. E. Ware	Lyons	Wayne				B. T	12
Titus, Henry Wm	Bellport	Suffolk	40 44	72 54	15	A.	12
Wadsworth, A. S.	Henrietta	Monroe	43 06	77 51	600	B. T. P.	12
Wakeley, Charles C., Rutherford's Observatory	New York	New York	40 44	73 59	41	A.	5
White, Aaron	Cazenovia	Madison	42 55	75 46	1,260	A.	12

NORTH CAROLINA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Adams, Prof. E. W.	Goldsborough	Wayne	35 20	77 51	102	T. R	3
Craven, Rev. B	Trinity College	Randolph	35 45	80 00	400	A.	1
McDowell, Rev. A.	Murfreesboro'	Hertford	36 30	77 01		A.	4
Moore, Geo. F., M. D.	Green Plains	Northampton	36 32	77 45		T. R	3
Phillips, Prof. James, D. D.	Chapel Hill	Orange	35 54	79 17		B. T. R.	4

OHIO.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Abell, B. F	Welshfield	Geauga	41 23	81 12	1,205	T. R	12
Adams, D. P.	Marietta	Washington	39 25	81 31	680	T. R	12
Ammen, J	Ripley	Brown	38 37	83 31		B. T. R.	3
Benner, J. F	New Lisbon	Columbiana	40 45	80 45	961	B. T. R.	12
Clark, Wm. P.	Medina	Medina	41 07	81 47	1,255	A.	12
Colbrunn, Edward	Cleveland	Cuyahoga	41 30	81 40	665	T.	12

OHIO—Continued.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	Feet.		
Cotton, D. B., M. D.	Portsmouth	Scioto	38 45	82 50	529	B. T. R.	12
Crane, George W	Bethel	Clermont	39 00	84 00	555	T. R	6
Davidson, H. M.; Davidson, Wilson	Freedom	Portage	41 13	81 08	1,100	B. T. R.	11
Dille, Israel	Newark	Licking	40 07	82 21	825	T	12
Fuller, W. G	Harmar	Washington	39 24	81 28	631	T	3
Hammitt, John W	College Hill	Hamilton	39 19	84 26	800	N	11
Harper, George W	Cincinnati	Hamilton	39 06	84 27	*500	A	12
Haywood, Prof. John	Westerville	Franklin	40 04	83 00	......	A	12
Hill, F. G	Dallasburg	Warren	39 30	84 31	800	N	12
Hillier, Rev. Spencer L.	Brecksville	Cuyahoga	41 15	81 30	800	A	2
Huntington, George C	Kelley's Island	Erie	41 36	82 42	587	B. T. R.	12
Hyde, Gustavus A	Cleveland	Cuyahoga	41 30	81 40	643	B. T. R.	12
Ingram, John, M. D	Savannah	Ashland	41 12	82 31	1,098	A	12
Johnson, Thos. H	Coshocton	Coshocton	40 18	81 53	765	A	4
King, Mrs. Ardelia C	Madison	Lake	41 50	81 00	620	T. R	12
Lumsden, Rev. Wm	West Union	Adams	38 47	83 28	......	T. R	1
McClung, Charles L	Troy	Miami	40 03	84 06	1,103	B. T. R.	12
McMillan, Smith B	East Fairfield	Columbiana	40 47	80 44	1,152	A	12
Newton, Rev. Alfred	Norwalk	Huron	41 15	82 30	......	T	12
Peck, Wm. R., M. D	Bowling Green	Wood	41 15	83 40	700	B. T. R.	12
Phillips, R. C. and J. H	Cincinnati	Hamilton	39 06	84 27	540	B. T. R.	12
Pierce, Warren	Garrettsville	Portage	41 15	81 10	900	T	6
Pillsbury, Mrs. M. A	East Cleveland	Cuyahoga	41 31	81 38	659	B. T	12
Shields, Rev. Robert	Bellecentre	Logan	40 30	83 45	1,170	B. T. R.	3
Spratt, Dr. Wm. W	Andrews	Morrow	40 45	80 45	1,500	T	4
Sperry, Mark; Thompson, Rev. E	Croton	Licking	40 13	82 38	......	T. R	12
Stuver, A. S	Western Star	Summit	41 04	80 40	......	T	6
Tappan, Eli T	Cincinnati	Hamilton	39 07	84 27	†470	A	5
Trembley, J. B., M. D	Toledo	Lucas	41 39	82 32	604	B. T	12
Ward, Rev. L. F	Seville	Medina	39 59	81 47	1,075	A	9
Warder, A. A	Cincinnati	Hamilton	39 08	84 35	800	T. R	12
Williams, Prof. M. G	Urbana	Champaign	40 06	83 43	1,015	B. T. R.	4
Wilson, Prof. J. H	College Hill	Hamilton	39 19	84 26	800	B. T. R.	12
Young, Prof. Chas. A; Barrows, A. C	Hudson	Summit	41 15	81 24	1,137	B. T. R.	12

OREGON.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Crawford, Thomas H	Salem	Marion	44 55	122 45	......	T. R	1

PENNSYLVANIA.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
Boyers, W. R	Latrobe	Westmoreland	40 20	79 16	569	T. R	1
	Blairsville	Indiana	40 31	74 43	1,010	T. R	3
Brugger, Samuel	Fleming	Centre	40 55	77 53	780	T. R	12
Coffin, Selden J.; Dean, Wm. H.; Kingsbery, J. H	Towanda	Bradford	41 47	76 34	840	B. T	7
Darlington, Fenelon	Parkersville	Chester	39 54	75 37	218	T. R	12
Eggert, John	Berwick	Columbia	41 05	76 15	583	A	9
Friel, P	Shamokin	Northumber'd	40 15	76 30	700	T. R.	12
Hance, Ebenezer	Morrisvillie	Bucks	40 12	74 48	30	B. T. R.	12
Heckerman, Rev. Henry	Bedford	Bedford	40 01	78 30	......	T. R	12
Heisely, Dr. John	Harrisburg	Dauphin	40 16	76 15	......	B. T. R.	12
Heyser, William, jr	Chambersburg	Franklin	39 58	77 45	618	A	11
Hickok, W. O	Harrisburg	Dauphin	40 20	76 50	320	A	12
Hoffer, Dr. Jacob R	Mount Joy	Lancaster	40 08	76 30	......	A	12
Houghton, George S	Easton	Northampton	40 43	75 16	320	A	12
Huebner, O. T	Nazareth	Northampton	40 43	75 21	530	B. T. R.	10
Jacobs, Rev. M; Eyster, D	Gettysburg	Adams	39 49	77 15	624	B. T. R.	12
Kohler, Edward	N. Whitehall	Lehigh	40 40	75 26	250	T	12
Lyceum, Jefferson College	Cannonsburg	Washington	40 17	80 10	936	A	10
Martin, R. A	Harrisburg	Dauphin	40 16	76 55	......	B. T. R.	3

*Above low water mark of Ohio river.
† Above low water in the Ohio river at Cincinnati.

PENNSYLVANIA—Continued.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	*Feet.*		
Martindell, Isaac	Byberry	Philadelphia	40 05	75 00	70	T. R.	10
Martindale, Jos. C., M. D.	Philadelphia	Philadelphia	40 05	75 09	....	N	1
Meehan, Thomas	Germantown	Philadelphia	....	....	....	N	12
Mowry, George	Somerset	Somerset	40 00	79 03	2,195	A	12
Muller, Prof. Rudolph	Latrobe	Westmoreland	40 27	79 32	985	B. T. R.	12
Ralston, Rev. J. Grier	Norristown	Montgomery	40 08	75 19	153	A	12
Saurman, Jonn W	Byberry	Philadelphia	40 00	74 49	....	T. R.	2
Scott, Samuel	Worthington	Armstrong	41 50	79 31	1,050	T. R.	12
Smith, Wm., D. D	Cannonsburg	Washington	40 17	80 10	936	B. T. R.	12
Speer, Alex. M., M. D	Pittsburg	Alleghany	40 32	80 02	850	B. T. R.	1
Swift, Dr. Paul	W. Haverford	Delaware	40 00	75 21	400	T. R.	12
Travelli, John I. / Tracy, George H	Sewickleyville	Alleghany	40 38	80 14	656	B. T. R.	12

RHODE ISLAND.

Caswell, Prof. A.	Providence	Providence	41 49	71 25	120	A	12
Sheldon, H. C	Providence	Providence	41 50	71 25	....	B. T. R.	12

SOUTH CAROLINA.

Cornish, Rev. John H	Aiken	Barnwell	33 32	81 34	565	T. R.	2
Glennie, Rev. Alexander	Georgetown	All Saints	33 29	79 17	20	A	4
Johnson, Joseph, M. D. / Dawson, J. L., M. D. / Pelzer, George S., M. D.	Charleston	Charleston	32 46	80 00	20	B. T. R.	9
Ravenel, Thomas P	Black Oak	Charleston	33 00	80 00	50	A	3

TENNESSEE.

Barney, Chas. R	University Pl	Franklin	35 12	86 00	2,000	B. T. R.	3
Dodge, J. W., & Son	Pomona	Cumberland	36 00	85 00	2,200	T	4
Jennings, S. K., M. D	Austin	Wilson	36 20	86 20	2,000	T. P. R.	5
Stewart, Prof. Wm. M	Clarksville	Montgomery	36 28	87 13	481	A	12
Mitchell, R. W., M. D	Memphis	Shelby	35 08	90 00	262	A	3

TEXAS.

Allis, Melvin H	Gonzales	Gonzales	29 35	97 30	....	N	3
Freese, G	Boston	Bowie	32 25	94 40	600	N	2
Gantt, Dr. Wm. H	Union	Washington	30 11	96 31	540	T. R.	2
Glasco, J. M	Gilmer	Upshur	32 46	94 51	950	T. R.	2
Kellog, F	Wheelock	Robertson	30 50	96 30	450	T. R.	1
Rayel, James	Turner's Point	Kaufman	32 30	96 00	....	T	1
Schumann, Bruno	Round Top	Fayette	30 06	96 37	....	T. R.	4
Van Nostrand, J	Austin	Travis	30 20	97 46	650	T. P. R.	4
West, Dr. N. P	Burkeville	Newton	31 00	93 31	....	T	4
Yellowby, Prof. C. W	Webberville	Travis	30 10	97 31	....	B. T. R.	4

UTAH.

Pearce, Harrison	Heberville	Washington	37 00	114 00	....	T. R.	9
Phelps, W. W	Great Salt Lake City	Salt Lake	40 45	111 26	4,260	A	11

VERMONT.

Name of observer.	Station.	County.	North latitude.	West longitude.	Height.	Instruments.	No. of months received.
			° ′	° ′	Feet.		
Buckland, David	Brandon	Rutland	43 45	73 00	....	T. R	12
Chickering, Rev. J. W	Springfield	Windsor	43 18	72 33	300	T. R	12
Cutting, Hiram A	Lunenburg	Essex	44 28	71 41	1,124	A	12
Fairbanks, Franklin	St. Johnsbury	Caledonia	44 25	72 00	540	B. T. R	1
Paddock, James A	Craftsbury	Orleans	44 40	72 29	1,100	T. R	12
Parker, Joseph	West Rupert	Bennington	43 15	73 11	750	T	5
Petty, McK	Burlington	Chittenden	44 27	73 10	367	A	12
Toby, James K	Calais	Washington	44 22	72 09	....	T. R	5

VIRGINIA.

Abell, J. Ralls	Charlottesville	Albemarle	38 00	78 31	521	T. R	4
Astrop, Col. R. F	Crichton's Store	Brunswick	36 40	77 46	500	T. R	1
Dickinson, George C	Cobham Depot	Albemarle	38 05	78 21	450	T. R	4
Ellis, D. H	Wardensville	Hardy	39 30	78 03	1,720	A	5
Fraser, James	New England	Wood	39 20	81 00	....	N	10
Jones, Silas B	Fork Union	Fluvanna	37 40	78 21	....	N	3
Kendall, James E	Kanawha C. H.	Kanawha	38 20	81 30	720	T. R	1
Meriwether, Charles I	Richmond	Henrico	....	....	....	T. R	4
Marvin, John W	Winchester	Frederick	39 15	78 10	....	T. R	4
Park, William K	Lexington	Rockbridge	37 41	79 25	....	A	3
Purdie, John R., M. D	Smithfield	Isle of Wight	37 02	76 37	100	T. R	3
Robey, Charles H	Fredericksburg	Spottsylvania	38 20	77 20	600	N	3
Roedel, W. D	Wytheville	Wythe	36 55	81 00	2,287	T. R	4
Stalnaker, J. W., M. D	Lewisburg	Greenbrier	37 49	80 28	2,000	T. R	3
Van Doren, Abram	Falmouth	Stafford	38 15	77 34	350	T. R	3

WISCONSIN.

Armstrong, S	Caldwell Prairie	Racine	42 48	88 13	....	T	11
Atwood, Isaac	Lake Mills	Jefferson	43 00	89 00	....	N	12
Bell, James H	Kilbourn City	Columbia	43 30	90 00	945	N	12
Curtis, W. W	Rocky Run	Columbia	43 26	89 20	....	T. R	12
Ellis, Edwin, M. D	Ashland	Ashland	46 33	91 00	610	T. R	8
Gridley, Rev. John	Kenosha	Kenosha	42 35	87 50	600	B. T. R	12
Kelley, Charles W	Delafield	Waukesha	43 08	88 36	900	B. T	12
Kelsey, Prof. Henry S	Beloit	Rock	42 30	89 04	750	B. T. R	12
Lapham, Increase A	Milwaukee	Milwaukee	43 03	87 56	593	A	12
Larkin, Prof. E. P	Milwaukee	Milwaukee	43 02	87 55	684	B. T	1
Lüps, Jacob	Manitowoc	Manitowoc	44 07	87 45	658	B. T	12
Mann, William	Superior	Douglas	46 46	92 03	680	T. R	12
Mason, Prof. R. Z	Appleton	Outagamie	44 10	88 35	800	A	12
Mathews, George	Burlington	Racine	42 39	....	700	N	12
Parker, Melzar	Weyaumega	Waupaca	44 15	88 50	870	T	5
Pease, Dr. Clark G	Janesville	Rock	42 43	89 09	780	T	10
Phelps, Hiland W	Racine	Racine	42 45	87 48	660	B. T	1
Towers, M. H	Dartford	Green Lake	43 30	89 25	....	B. T	10
Sterling, Prof. J. W; Fellows, William	Madison	Dane	43 05	89 25	1,068	A	10
Struthers, R. H	Rural	Waupaca	44 20	89 05	....	T	9
Winkler, Carl, M. D	Milwaukee	Milwaukee	43 03	87 57	600	B. T. R	8
Wood, William	Weyaumega	Waupaca	44 15	88 50	850	T	3

MEXICO.

Name of observer.	Station.	Latitude.	Longitude.	Height.	Instruments.	No. of months received.
		° ′	° ′	Feet.		
Laszlo, Charles	San Juan Bautiste, Tabasco	17 47	92 46	40	A	2
Sartorius, Charles	Mirador, Vera Cruz	19 15	96 25	3,600	A	12

CENTRAL AMERICA.

Name of observer.	Station.	Latitude.	Longitude.	Height.	Instruments.	No. of months received.
		° ′	° ′	Feet.		
Canudas, Antonio	Gautemala College, Gautemala..	14 37	90 30	4,856	A.......	12

WEST INDIES.

Carothers, A. G	Turk's Island	21 31	71 08	15	B. T ...	9
Garland, Samuel G.........	Salt Cay, Turk's Island..........	21 00	71 15	20	B. T	1

BERMUDA.

Royal Engineers, (in the Royal Gazette.)	Centre Signal Station, Saint George's.	.. ..	....	....	A	12

SOUTH AMERICA.

Hering, C. T...............	Government Plantation Rustenberg, colony of Surinam, Dutch Guiana.	....	....	....	A	8
Brown, George Hunter....	Jauja, Peru	12 00 S.	75 15	10,500	B. T. P..	1

DEATHS OF OBSERVERS.

George P. Lockwood, Wheeling, Virginia, early in 1860.
Dr. Thompson Mead, Batavia, Illinois, March 30, 1861.

Colleges and other institutions from which meteorological registers were received during the year 1861, *included in the preceding list.*

Nova Scotia............	Acadia College..................	Wolfville.
	King's College..................	Windsor.
Canada..............	Grammar School..................	Niagara.
	Magnetic Observatory.............	Toronto.
	University of McGill College.......	Montreal.
Alabama	Baptist Female Institute...........	Moulton.
California	University of the Pacific..........	Santa Clara.
Connecticut...........	Wesleyan University.............	Middletown.
Illinois..............	Lombard University..............	Galesburg.
	McKendree College...............	Lebanon.
	University of Chicago............	Chicago.
	Wheaton College.................	Wheaton.
Iowa.................	Cornell College.................	Mount Vernon.
	Griswold College................	Davenport.
	Iowa State University............	Iowa City.
	Yellow Spring College............	Kossuth.
Kentucky	Mount Alba College..............	Hardinsburg.
	St. Joseph's College.............	Bardstown.
Maine...............	Franklin School.................	Topsham.
	Oak Grove Seminary..............	Vassalboro'.
Maryland............	Agricultural College.............	Prince George county.
	Washington College..............	Chestertown.
Massachusetts.........	Amherst College................	Amherst.
	Normal School	Bridgewater.

Colleges, &c., from which meteorological registers were received, &c.—Continued.

Massachusetts	State Lunatic Hospital	Worcester.
	Williams' College	Williamstown.
Michigan	Marine Hospital	Detroit.
Missouri	St. Louis University	St. Louis.
New Jersey	Freehold Institute	Freehold.
New York	Genesee College	Lima.
	Institution for Deaf and Dumb	New York.
	St. John's College	Fordham.
	University of Rochester	Rochester.
	Young Men's Association	Buffalo.
North Carolina	Trinity College	Randolph county.
Ohio	Farmers' College	College Hill.
	Halcyon Academy	Croton.
	Otterbein University	Westerville.
	Urbana University	Urbana.
	Western Reserve College	Hudson.
	Woodward High School	Cincinnati.
Oregon	Wallamet University	Salem.
Pennsylvania	Haverford College	West Haverford.
	Jefferson College	Cannonsburg.
	Marine Hospital	Pittsburg.
	St. Vincent's College	Latrobe.
	Sewickleyville Academy	Sewickleyville.
	State Lunatic Hospital	Harrisburg.
	Susquehanna Collegiate Institute	Towanda.
Rhode Island	Brown University	Providence.
Tennessee	Stewart College	Clarksville.
Texas	Deaf and Dumb Asylum	Austin.
	Parsons' Seminary	Webberville.
Virginia	Virginia Military Institute	Lexington.
Wisconsin	Beloit College	Beloit.
	Lawrence University	Appleton.
	Milwaukee High School	Milwaukee.
	Racine College	Racine.
	Wisconsin University	Madison.
Central America	Guatemala College	Guatemala.

LIST OF METEOROLOGICAL MATERIAL CONTRIBUTED IN ADDITION TO THE REGULAR OBSERVATIONS.

Austin, E. P., Assistant U. S. Lake Survey.—Aurora noticed at Love Island, Lake Huron, in June, July, and August, 1860.

Blackwell, Thomas.—Daily means of observed temperatures during the year 1861, at two adjacent stations, Victoria Bridge and Point St. Charles, Montreal, Canada, at the hours of 9 a. m., noon, 3 p. m., and 6 p. m.; and also temperature of water of the River St. Lawrence, taken daily at noon; also a summary for the year. 8vo., pps. 13.

Table showing the proportion of rain at Montreal, Canada, due to winds bearing rain from the surrounding regions, for the year 1859.

Boettner, Gustav A.—Original drawings of forty-three different forms of snow crystals, made during 1861 and 1862, at Chicago, Illinois.

Brackett, George Emerson.—Monthly summaries of observations made at Belfast, Maine, in 1861; published in the "Republican Journal."

Buchner, Dr. Otto.—Analyse des Meteoreisens von Rasgata in Neugranada, von Prof. Wöhler in Göttingen, mit notizen über das Vorkommen und die physikalischen Eigenschaften desselben von Director Partsch, wirklichem mitgliede der Kaiserlichen Akademie der Wissenschaften. Mit einer tafel. 8vo. pp. 11.

Über den Meteorsteinfall bei Ohaba im Blasendorfer Bezirke in Siebenbürgen, in der Nacht zwischen dem 10. und 11. October, 1857. Von Dr. Moriz Hörnes, vorstand des k. k. Hof-Mineralien-Cabinets. Wien, 1858. 8vo., pp. 8.

Über den Meteorsteinfall bei Kaba, südwestlich von Debreczin, am 15. April, 1857. Von Dr. Moriz Hörnes. Mit einer Tafel. Wien, 1858. 8vo., pp. 6.

Die organische Substanz im Meteorsteine von Kaba. Schreiben des correspondirenden Mitgliedes Fr. Wöhler an Dr. Hörnes, mitgetheilt von W. Haidinger, wirklichem Mitgliede der Kaiserlichen Akademie der Wissenschaften. 8vo., pp. 2.

Der Meteoreisenfall von Hraschina bei Agram am 26. Mai, 1751. Von W. Haidinger. Wien, 1859. 8vo., pp. 30.

Notiz über das Meteoreisen von Nebraska. Von W. Haidinger. 8vo., pp. 3.

Das Doppelmeteor von Elmira und Long Island. Von W. Haidinger. 8vo., pp. 4.

Der Meteorsteinfall von Parnallee, bei Madura, in Hindostan. Von W. Haidinger. 8vo., pp. 3.

Neuere Untersuchungen über die Bestandtheile des Meteorsteines vom Capland. Schreiben des Fr. Wöhler an W. Haidinger. 8vo., pp. 3.

Über das von Herrn J. Auerbach in Moskau entdeckte Meteoreisen von Tula. Von W. Haidinger. Moskau, 1861. 8vo., pp. 15.

[The above ten papers on Meteors are also published in the Transactions of the "Kaiserliche Akadamie der Wissenschaften," at Vienna.]

Die Feuermeteore, insbesondere die Meteoriten historisch und naturwissenschaftlich betrachtet, von Dr. Otto Buchner. Giessen, 1859. 8vo., pp. 192.

Versuch eines Quellenverzeichniss zur Literatur über Meteoriten, von Dr. Otto Buchner. Frankfurt a. M., 1861. 4to, pp. 17.

Canudas, Antonio.—Printed summary of observations with a full set of instruments, for the year 1861, made at the college in charge of the Jesuit Fathers of Guatemala.

Caswell, Prof. Alexis, D. D.—Monthly summaries of observations made at Providence, R. I., during 1861; published in the "Providence Daily Journal."

Dawson, William.—Thermometer observations at Cadiz, Indiana, for the years 1857, 1858, 1859.

Hourly thermometer observations from 4 a. m. to 9 p. m., during October, November, and December, 1861.

Dewey, Rev. Chester, D. D.—Printed summary of observations at Rochester, N. Y., for the year 1861.

Gardiner, R. H.—Printed summary of observations at Gardiner, Maine, for the year 1861, and the means of twenty-four years.

Graham, Lieut. Col.—Annual report of Brevet Lieutenant Colonel J. D. Graham, Major U. S. Topographical Engineers, on the improvement of the harbors of Lakes Michigan, St. Clair, Erie, Ontario, and Champlain, for the year 1860. (The volume contains half hourly observations from January 1 to July 1, 1859, on the rise and fall of the surface of Lake Michigan, and discussions to establish a lunar tide on the lake.)

Heimstreet, John W.—Printed summary of observations at Troy, N. Y., for the year 1861; published in the "Troy Daily Budget" newspaper.

Hewitt, C. H.—Barometer and thermometer observations taken at 6 a. m., noon, and midnight, on steamer between San Francisco and Panama, in August and September, 1861.

Hildreth, S. P., M. D.—Monthly registers for the year 1861, at Marietta, Ohio, completing his series of observations from 1824. The whole series has been received at the Institution, and reduced preparatory to publication.

Kaiserliche Geographischen Gesellschaft zu St. Petersburg.—Repertorium für Meteorologie, herausgegeben von der Kais. Geographischen Gesellschaft zu St. Petersburg, redigirt von Dr. Ludwig Friedrich Kämtz, Kaiserl. Russischern Staatsrath und Professor zu Dorpat. Dorpat, 1859, 1860. 4to.

Kingston, G. T.—Mean meteorological results at Toronto, Canada, for the year 1861, by G. T. Kingston, M. A., Director of the Magnetical Observatory, Toronto.—(From the Canadian Journal for March, 1862.) 8vo., pp. 8.

Kongelige Danske Videnskabernes Selskabs, Copenhagen, Denmark.—Collectanea meteorologica, sub auspiciis Societatis Scientiarum Danicæ edita :

Fasc. I. Observationes meteorologicæ a cal. Juniis, 1824, ad cal. Junias, 1825, Apenroæ in Ducatu Slesvicensi factæ ab A. Neuber, Doctore Philosophiæ, Medicinæ et Chirurgiæ, urbis et præfecturæ Apenroensis Physico. Hafniæ, 1829. 4to., pp. 246.

Fasc. II. Observationes meteorologicæ a 1 Jan., 1823, ad 1 Aug., 1837, in Islandia factæ, a Thorstensenio, Medico. Hafniæ, 1839. 4to., pp. 234.

Fasc. III. Observationes meteorologicæ per annos 1829–'34, et 1838–'42, in Guinea factæ, a J. J. Trentepohl, R. Chenon, F. Sannom. Hauniæ, 1845. 4to., pp. 136.

Kongliga Svenska Vetenskaps-Akademien, Stockholm, Sweden.—Meteorologiska Iakttagelser i Sverige utgifna af Kongl. Svenska Vetenskaps-Akademien bearbetade af Er. Edlund. Första bandet, 1859. Stockholm, 1860. Oblong 4to, pp. 108.

Koniglich Preussische Statistiches Bureau, Berlin, Prussia.—Uebersicht der Witterung im nōrdlichen Deutschland nach den Beobachtungen des Meteorologischen Instituts zu Berlin. 1859, 4to, 28 pp.; 1860, 4to, 32 pp.

Koninklijk Nederlandsch Meteorologisch Instituut, Utrecht, Holland.—Uitkomsten van Wetenschap en Ervaring aangaande Winden en zeestroomingen in sommige gedeelten van den Oceaan. Uitgegeven door het Koninklijk Nederlandsch Meteorologisch Instituut. 2e omgewerkte druk. Utrecht, 1856. 4to, pp. 163.

Lake Winnepissiogee Cotton and Woollen Manufacturing Company, N. H.—Amount of rain for each month in 1861, at the outlet of Lake Winnepissiogee, in the town of Laconia, and also at Lake Village, about four miles south on the same stream of water. (Similar statements have been previously received for the years 1857 to 1860.) Transmitted by Josiah W. French.

Lapham, Increase A.—Notes of Periodical Phenomena and weather, made at Hudson, N. Y., 1790 to 1794, copied from an interleaved almanac.

Lewis, James.—Hourly mean temperature at Mohawk, N. Y., for the year 1861, and several shorter periods. Also fac simile specimens of the records made by his metallic self-recording thermometer.

Martindale, Isaac.—Summary of observations made at Byberry, Pennsylvania, during the year 1861.

Martins, Professor Ch.—Essai sur la Théorie de la Variation diurne barométrique, sur la Constitution de l'Ether, et sur Analogie de ce Fluide avec la Fluide électrique. Mémoire présenté à la Société Académique de l'Aube par le Docteur C. L. Henry, membre associé. Troyes, 1860. 8vo., pp. 144.

Annuaire Meteorologique de France pour 1850, 1851, 1852. 8vo.

Du Froid Thermometrique et de ces relations avec le Froid Physiologique dans les Plaines et sur les Montagnes. Montpellier, 1859. 4to, pp. 52.

Sur le Froid exceptionnel qui a regné à Montpellier dans le courant de Janvier, 1855, les differences notables de temperature observés sur des points tres-rapproches et leur influence sur la vegetation. Montpellier, 1855. 4to, pp. 16.

Essai sur la nature et l'origine des differentes espéces de Brouillards secs. Versailles, 1850. 8vo. pp. 21.

Des causes du Froid sur les hautes Montagne. Paris, 1860. 8vo., pp. 38.

Des climats de la France et de leur influence sur son agriculture et la genie de ses habitants. Versailles, 1850. pp. 26.

Mémoire sur les températures de la Mer Glaciale à la surface, à de grand profondeurs, et dans le voisinage des Glaciers du Spitzberg. Paris, 1848. 8vo., pp. 72.

Meade, Capt. George G.—Register of water-level and meteorological observations from January to June, 1861, under the direction of Captain George G. Meade, U. S. Topographical Engineers, Superintendent Survey of the North and Northwestern Lakes, as follows:

Sackett's Harbor, N. Y., by Henry Metcalf.
Charlotte, N. Y., by Andrew Mulligan.
Fort Niagara, N. Y., by Louis Leffman.
Monroe Piers, Mich., by John Lane.
Thunder Bay Island, Mich., by I. I. Malden.
Ottawa Point, Mich., by John Oliver.
Grand Haven, Mich., by Heber Squier.
Ontonagon, Mich., by Henry Selby.
Superior, Wis., by George R. Stuntz, assisted by E. H. Bly.

Meteorological Society of Scotland.—Quarterly reports and other regular publications of the society.

Fall of rain at thirty-seven stations in Scotland during each month in the year 1856; published in the Edinburg New Philosophical Journal for April, 1857.

Fall of rain at fifty-five stations in Scotland during each month in 1857. Edinburg New Philosophical Magazine, April, 1858.

Morris, Prof. O. W.—Summary of observations from 1854 to 1860, inclusive, kept at the Institution for Deaf and Dumb, New York.

Muller, Prof. Dr. Rudolph.—Summaries and diagrams of observations made at St. Vincent's College, Westmoreland county, Pennsylvania, during the year 1861.

Nason, Rev. Elias.—Record of events, meteorological and general, in Exeter, N. H., during the year 1861. Pamphlet, pp. 16.

Naturforschende Gesellschaft, Emden, Hannover.—Die Thermische Windrose für Nordwest Deutschland, von Dr. M. A. F. Prestel. Mit vier figurentafeln. Eingegangen bei der Akademie am 18 Nov. 1860. (Besondrer abdruck aus Band XXVIII, der Verhandlungen der K. L.-C. D. A.) Jena, 1861. 4to, pp. 36.

Meteorologische untersuchungen betrefferd die verbreitung des Moorrauchs in den Tagen vom 20. bis 26. Mai, 1860, die isobaromotrischen Linien am 22. Mai und die Gewitter am 20. und 26. Mai, 1860. Von Dr. M. A. F. Prestel. Kleine schriften der Naturforschenden Gesellschaft im Emden VIII. Mit 2 tafeln in steindruck. Emden, 1861. 4to, pp. 24.

Bildliche Darstellung des Ganges der Witterung vom 1. December, 1859, bis 30. November, 1860, im Königreich Hannover. Nach den Beobachtungen der meteorologischen stationen entworfen von Dr. M. A. F. Prestel.

Navy Department, Bureau of Medicine and Surgery.—Monthly registers kept at—

Naval Hospital, Chelsea, Mass., year 1861.
Naval Hospital, New York, year 1861.
Naval Hospital, Philadelphia, year 1861.
Naval Hospital, Portsmouth, Va., January, February, and March, 1861.

Observatoire Impérial, Paris.—Daily meteorological observations, by telegraph, from various parts of Europe. (Lithograph.)

Reale Osservatorio, Palermo, Italy.—Giornale Astronomico e Meteorologico del Reale Osservatorio di Palermo, publicato dal Prof. Domenico Ragona. Vol. 1. Palermo, 1855. 4to, pp. 188.

Ross, Bernard R., Chief Factor of Hudson's Bay Company.—Observations at Lake Nipegon, from October 1, 1841, to June 13, 1845. Thermometer at 6 a. m., noon, and 10 p. m.; wind, weather, and remarks. No thermometer after March 25, 1845; instrument broken. Register kept by James Anderson, chief factor.

Observations at Fort Simpson, Mackenzie's river, Hudson's Bay Territory, from November 1, 1837, to May 24, 1839. Thermometer observed in morning, afternoon, and evening; wind and weather in a. m. and p. m.

Saunders, Henry D.—Results of the meteorological observations made at the observatory at Vilna, Russia, from June, 1860, to May, 1861; and at Warsaw in 1860. (2 pages.)

Schmid, Dr. Ernst Erhard.—Lehrbuch der Meteorologie bearbeitet von Dr. Ernst Erhard Schmid, Professor zu Zena. Nebst einem Atlas von 21 tafeln. Leipzig, 1860. 8vo., pp. 1010.

Atlas von einundzwanzig Kuppertafeln zu Ernst Erhard Schmid's Lehrbuch der Meteorologie. (Allgemeine Encyklopädie der Physik, xxi. Band.) Leipzig, 1860. Oblong 4to.

Sheldon, H. C.—Monthly and annual summaries of observations at Providence, R. I., during the year 1861; published in the "Evening Press."

Smith, Rev. L. M. S.—Summary of observations made at Mill Point, Michigan, during the year 1861; published in the "Grand Haven News."

Smallwood, Dr. Charles.—Contributions to Meteorology for the year 1860, reduced from observations at Isle Jesus, Canada East, by C. Smallwood, M. D., L.L. D., Professor of Meteorology in the University of McGill College, Montreal. 8vo., pp. 4.

Same for 1861, 10 pages.

State Department.—Statistics of the weather and health at Frankfort-on-the-Mayne during the year 1861, by William M. Murphy, U. S. Consul General at Frankfort.

Sternbergh, W. H.—Register of thermometer and face of sky at Panama, in July and August, 1861. (Newspaper.)

Tolman, James W.—Summary of observations made in 1861 at Winnebago, Illinois; published in the "Rockford Register."

Wagner, W. H., Chief Engineer of the Fort Kearney, South Pass, and Honey Lake Wagon Road. Expedition.—Record of barometer, thermometer, winds, and clouds, made on the route of the expedition, May 29, to August 16, 1860.

Whitehead, W. A.—Monthly and annual summaries of observations made during the year 1861, at Newark, New Jersey; published in the "Sentinel of Freedom and Weekly Advertiser."

Unknown.—Summary of the meteorology of St. John, New Brunswick, for October, 1861, in the "Morning Freeman" of November 9, signed "M."

CATALOGUE OF ENGRAVINGS

PRESENTED TO THE SMITHSONIAN INSTITUTION BY C. B. KING, DECEMBER, 1861.

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1. Jupiter and Leda. From a picture by F. Vieira, a Portuguese.
2. Apollo. *Cazenave, del et sculpt.*
3. Venus and Adonis. B. West. (Bn. 1738, obt. 1820.)
4. Jupiter and Semele. West. *Cook, sculpt.*
5. Alfred the Great. West. *Sharp, sculpt.*
6. Adoration of Virgin. Rubens. (Bn. Cologne, 1577, obt. 1640.) *Sayers, sculpt.*
7. Mucius Scevola. Rubens. *Marchand, sculpt.*
8. Massacre of Innocents. Rubens. (Engraved by Pontius, 1643.)
9. Landscape. J. Asselyn. (Flemish, 1610 and 1660.) *Major, sculpt.*
10. Dividing the Booty. Simonini. (Bn. Parma, 1689, obt. 1760.) *Vivares, sculpt.*
11. Christ in Tempest. Rembrandt. (Bn. 1606, obt. 1665.)
12. Trial of Christ. (Etching, 1636.) Rembrandt.
13. Nymphs Bathing. Dietricy. (Ser. 1712.)
14. St. Sebastian. Titian. (1477 to 1576.) *Cunego. sculpt.*
15. Charles Seymour. Titian. *Baron, sculpt.*
16. Apollo. (1590)
17. Paris and Helen. (Unknown.)
18. Virgin, Child, and St. John. Van Dyck. (Bn. 1599.) *V. Green, sculpt.*
19. Charles I and Duke d'Espernon. Van Dyck. *Baron, sculpt.*
20. Charles I and Court. Van Dyck. *Baron, sculpt.*
21. Viscount Fordwich. Van Dyck. *Baron, sculpt.*
22. Cartoon, the Annunciation. (Coll. Soc. Jesus.) Cornelio. Engraved 1571.
23. Golden Calf. N. Poussin. (1594, 1665.) *Baudet, sculpt.*
24. Woman taken in Adultery. N. Poussin.
25. Architectural Designs. M. Angelo. 6 plates.
26. The Cardinal Virtues. Domenichino. *Frey, sculpt.* They consist of four plates, viz:
    - A. *Justitia.*
    - B. *Temperantia.*
    - C. *Fortitudo.*
    - D. *Prudentia.*
27. Bacchanals. Cesius.
28. Battle Scene. (Alex. Great.) Pietro Berretini, born 1596, called Da Cortona. Florentine.
29. Battle Scene. (Unknown.)
30. Diana and Acteon. P. Morelze. Dutch, 1571. *Mœtham, sculpt.*
31. Scene from Roman History. Giulio Romano. (1492, Rome.)

32. Scene from Roman History. Giulio Romano.
33. Dance of the Hours. Giulio Romano.
34. Diana and Acteon. Carlo Maratti. (Bn. 1625.)
35. Mary Washing Christ's Feet. P. Veronese or Cagliari. (Bn. Verona, 1532.)
36. Ancient Naval Show in Circus. P. Veronese.
37. Last Supper. P. Veronese. *Saenredam, sculpt.*
38. Le Testament Dechire. J. B. Greuze. (French, 1726.) *Levabeur, sculpt.*
39. Le Veuve et Son Cure. J. B. Greuze. *Levabeur, sculpt.*
40. Le Gateau des Rois. J. B. Greuze. *Flipart, sculpt.*
41. Death of Oedipus. Fuseli. (Swiss. Lived in London. 1741—1825.) *Ward, sculpt.*
42. Caractacus. Fuseli. *Birrell, sculpt.*
43. French Second Rate Ship. Vandervelde. *Tompins, sculpt.*
44. Spanish Second Rate Ship. Vandervelde.
45. Nymphs Bathing. Jos. Vernet. (Bn. 1714.) *Laurie, sculpt.*
46. Celadon and Amelia. R. Wilson, R. A. (1714—1782.) *Woollett, sculpt.*
47. Mine of Fahlun. Vanlerberghe. *Malgo, sculpt.*
48. Venus Aphrodite. Jas. Barry, R. A. (1741—1806.) *Green, sculpt.*
49. Vulture. Northcote, R. A. (1746—1831.) *Reynolds, sculpt.*
50. Heron. Northcote, R. A. *Reynolds, sculpt.*
51. Death of Captain Faulknor. Stothard, R. A. (1755—1834.) *Blackberd, sculpt.*
52. Marriage at Cana. J. B. Jackson.
53. Dutchess Yorke. Hoppner. (German. Born in London. 1759—1810. *Dickinson, sculpt.*
54. Mrs. Whitebread. Hoppner. *Reynolds, sculpt.*
55. Duke of Leeds. Lawrence, R. A. (1769—1830.) *Meadows, sculpt.*
56. Infant Hercules. Reynolds. (1723—1838.) *Walker, sculpt.*
57. Sir Wm. Hamilton. Reynolds. *Hudson, sculpt.*
58. Duke of Clarence? Reynolds. *Watson, sculpt.*
59. George IV as Prince of Wales. Reynolds. *Haward, sculpt.*
60. Duke of Yorke. Reynolds. *Jones, sculpt.*
61. Sir J. Leicester. Reynolds. *S. Reynolds, sculpt.*
62. Lord Romney. Reynolds. *Finlayson, sculpt.*
63. Lord R. Manners. Reynolds. *Dickinson, sculpt.*
64. Mrs. Siddons as Tragic Muse. Reynolds. *Haward, sculpt.*
65. L'Allegro. Reynolds. *Watson, sculpt.*
66. Viscountess Townshend. Reynolds. *Green, sculpt.*
67. Hon. Mrs. Parker. Reynolds. *Watson, sculpt.*
68. Hon. Lady Delme. Reynolds. *Green, sculpt.*
69. Viscountess Crosbie. Reynolds. *Dickinson, sculpt.*
70. Mrs. Blake. Reynolds. *Dixon, sculpt.*
71. Lady Talbot. Reynolds. *Green, sculpt.*
72. Mrs. Tollemache. Reynolds. *Jones, sculpt.*
73. (Unknown.)
74. Balbec. (Ruins, 5 plates.)
75. Design. (Gateway to Carlton House.)

REPORT OF THE EXECUTIVE COMMITTEE.

The Executive Committee respectfully submit to the Board of Regents the following report of the receipts and expenditures of the Smithsonian Institution during the year 1861, with general estimates for the year 1862.

RECEIPTS.

The whole amount of Smithson's bequest deposited in the treasury of the United States is $515,169, from which an annual income at six per cent. is derived of	$30,910 14
The extra fund of unexpended income is invested, as follows, viz :	
In 75,000 Indiana 5 per cent. bonds, yielding	3,750 00
In 53,500 Virginia 6 per cent. bonds, yielding nothing during 1861.	
In 12,000 Tennessee 6 per cent., yielding nothing during 1861.	
In 500 Georgia 6 per cent., yielding nothing during 1861.	
In 100 Washington 6 per cent., will be paid, but not collected in 1861.	
Total income	34,660 14
Balance in the hands of the treasurer, Jan. 11, 1861	16,521 95
Total receipts	51,182 09

EXPENDITURES

For building, furniture, and fixtures	$1,734 62	
For general expenses	10,899 69	
For publications, researches, and lectures	10,764 96	
For library, museum, and gallery of art	5,737 65	
Total expenditure		29,136 92
Balance in the hands of the treasurer, January 9, 1862		22,045 17

Statement in detail of the expenditures during 1861.

BUILDING, FURNITURE, AND FIXTURES.

Building incidentals	$906 19	
Furniture and fixtures in general	177 26	
Furniture and fixtures for museum	651 17	
		$1,734 62

GENERAL EXPENSES.

Meetings of the board	$66 00	
Lighting and heating	1,074 94	
Postage	389 08	
Transportation, general	656 24	
Exchanges	793 07	
Stationery	194 60	
General printing	50 16	
Apparatus	711 70	
Laboratory	161 42	
Incidentals, general	400 38	
Extra clerk hire	434 10	
Salaries, secretary	3,500 00	
chief clerk, bookkeeper, messenger, and laborers	2,468 00	
		10,899 69

PUBLICATIONS, RESEARCHES, AND LECTURES.

Smithsonian Contributions	$3,936 85	
Smithsonian Reports	915 00	
Smithsonian Miscellaneous Collections	1,627 63	
Other publications	310 50	
Meteorology	3,059 04	
Researches and investigations	111 00	
Lectures	804 94	
		10,764 96

LIBRARY, MUSEUM, AND GALLERY OF ART.

Cost of books and binding	$915 78	
Pay of assistants in library	1,141 00	
Transportation for library	126 87	
Incidentals for library	23 12	
Museum, salary of assistant secretary	2,000 00	
Transportation for museum	406 33	
Incidentals for museum	477 35	
Explorations	432 25	
Gallery of art	214 95	
		5,737 65
Total expenditures		29,136 92

On account of the delay in obtaining the interest due from the United States at the beginning of the year, the foregoing accounts for 1861 were made up to the 9th of January, 1862.

It will be seen that the whole income during the year 1861 was $34,660 14, instead of the estimated income of $38,626 14. This difference is caused by the failure of Virginia, Tennessee, and Georgia to pay the interest on their bonds, and by the treasurer not having as yet collected the $6 from the corporation of Washington.

The expenditures during 1861 were $29,136 92, leaving $5,523 22 to be added to the balance in the hands of the treasurer on the 11th of January, 1861, making $22,045 17 in hand for paying in cash the expenses of the operations of the Institution as rapidly as the bills are presented.

The foregoing statement is an actual exhibit of the Smithsonian funds irrespective of credits and disbursements which have been made in behalf of other parties. For example: the Institution frequently advances money to pay for the transportation of packages in connexion with its general system of exchange, and in all such cases the money when refunded is credited to the appropriation from which the expenditure was originally made. Again: the use of the lecture room is, in many instances, granted for charitable and literary purposes without any other charge than that for the gas consumed and the pay of the necessary attendants, the whole amounting to ten dollars each night. Half of this is credited on the books of the Institution to the account of "lighting and heating," and the other half paid directly to the persons employed.

The appropriation from Congress for the preservation of the collections of the exploring and surveying expeditions of the United States has been expended as usual, under the direction of the Secretary of the Interior, in assisting to pay the expenses of extra assistants in the museum, and the cost of arranging and preserving the specimens. The sum received from this source has been credited to the museum, and has served to diminish the amount of expenditures for that object on the part of the Institution, although it has by no means been sufficient to defray all the expenses to which the establishment has been subjected, on account of the preservation and public exhibition of the specimens.

The articles intrusted to the care of the Institution are in good condition, and the work of the distribution of the duplicates of the government as well as those of the Institution is in active progress.

A part of the expenditure on the building is due to the introduction of the Potomac water, but a further expenditure during the present year will be required for the same purpose.

Although the income of the Institution during 1861 has been nearly $4,000 less than was estimated at the beginning of the year, yet the Secretary, by a proper curtailment of the operations in view of the unsettled condition of the times, has reduced the expenditures to $5,000 less than the actual income. All the outstanding obligations of the Institution for works which have been commenced would not exceed $2,000, so that the establishment could to-day wind up

its affairs with $20,000 in cash, besides the undiminished original bequest of Smithson in the treasury of the United States, and $141,000 invested in State stocks, from which it is hoped at some future time the full interest may be received.

It is impossible, in view of the uncertainty of the future, to present even an approximate estimate of the expenditures during 1862. The committee would, however, submit the following as a general guide to the Secretary:

Estimated income		$34,666 14
Estimated expenditure:		
For building, furniture, and fixtures	$2,000 00	
For general expenses	10,500 00	
For publications, researches, and lectures	10,500 00	
For library, museum, and gallery of art	9,000 00	
		32,000 00

The committee have carefully examined the books and accounts of the Institution for the past year, and find them to be correct.

Respectfully submitted.

J. A. PEARCE,
A. D. BACHE,
J. G. TOTTEN,
Executive Committee.

JOURNAL OF PROCEEDINGS

OF THE

BOARD OF REGENTS

OF

THE SMITHSONIAN INSTITUTION.

WASHINGTON, *January* 15, 1862.

In accordance with a resolution of the Board of Regents of the Smithsonian Institution, fixing the time of the beginning of their annual session on the third Wednesday of January of each year, the Board met this day in the Regents' room at 11 o'clock a. m.

Present: Hon. H. Hamlin, Hon. J. A. Pearce, Hon. E. McPherson, Hon. S. S. Cox, Hon. Richard Wallach, and the Secretary.

The Secretary stated that since the last session of the Regents the following changes had taken place in the Board, viz:

Hon. HANNIBAL HAMLIN, as Vice-President of the United States, has become *ex officio* a member of the Board. The vacancy occasioned by the death of Hon. Richard Rush, has by joint resolution of Congress, approved March 2, 1861, been filled by the appointment of Hon. WILLIAM L. DAYTON, of New Jersey; the vacancy caused by the expiration of the term of Hon. Gideon Hawley, by the appointment of WILLIAM B. ASTOR, of New York; and that by the expiration of the term of CORNELIUS C. FELTON, of Massachusetts, by the reappointment of the same gentleman.

The Secretary also stated that on the 7th of March, 1861, the Vice-President of the United States reappointed Hon. JAMES A. PEARCE a Regent for the term of six years, and on the 4th of December, 1861, he appointed Hon. W. P. FESSENDEN, of Maine, and Hon. L. TRUMBULL, of Illinois, to fill the vacancies occasioned by the decease of Hon. S. A. Douglas and the removal of Hon. J. M. Mason; and that on the 19th of December the Speaker of the House appointed Hon. S. COLFAX, of Indiana, Hon. S. S. Cox, of Ohio, and Hon. E. McPHERSON, of Pennsylvania, as Regents for the term of two years.

In addition to the foregoing, Hon. RICHARD WALLACH having been

chosen Mayor of the city of Washington, in place of Mr. Berret, resigned, has become *ex officio* a member of the Board.

The Secretary made a statement relative to the present condition of the Institution and its operations, but as several of the Regents were obliged to leave on account of congressional duties, the Board adjourned to meet on Saturday, February 8.

SATURDAY, *February* 8, 1862.

The Board of Regents met this day at 10 o'clock a. m. in the Regents' room.

Present: Hon. H. Hamlin, Vice-President of the United States; Hon. James A. Pearce, Hon. Lyman Trumbull, Hon. S. Colfax, Hon. S. S. Cox, Hon. Edward McPherson, Hon. R. Wallach. In the absence of the Chancellor, Hon. Mr. Hamlin was called to the chair.

Mr. Pearce presented the report of the Executive Committee, containing an account of the receipts and expenditures for the year 1861, and estimates for 1862, which was read and approved.

Mr. Pearce also gave an account of the financial arrangements of the Institution, the care exercised in expenditures, the examination of vouchers, &c.

1. The disbursements are authorized by the Secretary, in accordance with the appropriations made by the Board.

2. The accounts are audited by the Chief Clerk, and in the more important cases are examined by experts as to the reasonableness of the charges.

3. The bills are next presented to the Secretary for approval and for orders on the Treasurer to pay them.

4. They are then copied in detail into a day-book in chronological order, and the amounts posted in a ledger under the heads of the different appropriations.

5. The accounts and vouchers are semi-annually placed in the hands of Mr. W. B. Randolph, (Chief Clerk of the Treasurer of the United States,) for critical and final revision, and for the preparation of a general statement of receipts and expenditures during the year.

6. At the end of the year all the books and accounts are carefully examined by the Executive Committee, and the result reported to the Board of Regents.

The Secretary presented his annual report of the operations of the Institution during the year 1861, which was read and approved.

The Board then adjourned to meet at the call of the Secretary.

WASHINGTON, *May* 1, 1862.

The Board of Regents met this day at ten o'clock a. m. in the Regents' room.

Present: Hon. L. Trumbull, Hon. Edward McPherson, Hon. R. Wallach, General J. G. Totten, Professor A. D. Bache, Dr. Theodore D. Woolsey, and the Secretary.

General Totten was called to the chair.

The minutes were read and approved.

The Secretary announced that since the last meeting of the Board Dr. C. C. FELTON had deceased, and that Congress had by joint resolution appointed THEODORE D. WOOLSEY, LL. D., President of Yale College, to fill the vacancy thus occasioned.

Professor Bache, after a few appropriate remarks, offered the following resolutions, which were unanimously adopted:

Resolved, That the Board of Regents of the Smithsonian Institution deeply mourn the loss of their fellow-regent, Cornelius Conway Felton, the distinguished President of Harvard University, whose profound learning and ready use of the rich stores of ancient and modern lore excited general admiration, while his genial temper, affectionate disposition, and open manners, endeared him as a friend to every member of this establishment.

Resolved, That in the death of President Felton our country, in the hour of its trial, has lost a wise and influential citizen, our government a warm and eloquent supporter, Harvard University a learned and efficient head, and this Institution an active and valued regent.

Resolved, That we sincerely condole with the bereaved family of President Felton, and offer to them our heartfelt sympathy in their deep affliction.

Resolved, That Dr. Woolsey be requested to prepare a suitable notice of President Felton, to be inserted in the Journal of the Board of Regents.*

Resolved, That a copy of these resolutions be communicated by the Secretary of the Smithsonian Institution to the family of the deceased, and to the Faculty and Corporation of Harvard.

Hon. Mr. Trumbull made some remarks relative to the late Judge Douglas, and offered the following resolutions:

Resolved, That in the death of the Hon. Stephen A. Douglas the Smithsonian Institution has been deprived of a most zealous friend; the Board of Regents of an active and attentive member; and the country of a distinguished and influential citizen.

Resolved, That the Board of Regents deeply sympathize with the

* Dr. Woolsey's eulogy will be found at the end of these proceedings, page 109.

bereaved relatives of the deceased, and that a copy of these resolutions be transmitted to them.

Resolved, That the Hon. S. S. Cox be requested to prepare a suitable notice of the Hon. S. A. Douglas to be inserted in the Journal of the Board of Regents.*

The resolutions were unanimously adopted.

The Secretary stated that during a recent visit of Rev. Francis Vinton to Washington he had obtained from him some additional facts relative to the Wynns estate, of which the Smithsonian Institution is the provisional legatee.

Mr. Thomas Wynns, born in North Carolina, resided for a long time at Grand Turk, Turk's Island, where he accumulated a considerable fortune, and married at an advanced age Charlotte Arthur, a daughter of John Arthur, a woman much younger than himself. He afterwards removed to Brooklyn, New York, where he died about 1851, leaving his widow and one child, a daughter. To the former he bequeathed a life annuity of $1,500, and to the latter his whole estate, subject to the foregoing annuity. In case of the death of this daughter without issue, the estate, now valued at from $60,000 to $70,000, is bequeathed to the Smithsonian Institution. The property is securely invested in bonds and mortgages, and is under the care of Edw. Coffin, now residing in London, and Rev. Francis Vinton, of Trinity church, New York, as trustees. The accounts are rendered to the surrogate of Kings county, New York.

After the death of her husband, Mrs. Wynns returned to the West Indies and married Captain Anderson. She now resides, with her daughter Charlotte Arthur Wynns, in England. The latter is about seventeen years of age.

The Secretary gave an account of the circumstances connected with the money left in England by Hon. Richard Rush, as the principal of an annuity to the mother of the nephew of Smithson, and presented the following communications from Fladgate, Clarke & Finch, of London.

40 Craven street, Strand,
London, W. C., May 16, 1861.

Sir: We had the honor, in the year 1838, of acting professionally for the President of the United States in the suit in the English court of chancery, under which the funds for the foundation of the Institution (of which we address you as the manager) were decreed to be

* This eulogy will be found at the end of these proceedings, page 117.

paid over to him for the purpose of establishing the Institution. We have now to make to you as the manager thereof the following communication:

On referring to the papers connected with the Institution you will find that a sum of £5,015 three per cent. consols, part of the estate of Smithson, the founder, were retained in the court of chancery to answer a claim of one Madame de la Batut. That person was, in fact, entitled to a life interest in the fund, and at her death it was to revert to the President as an additional fund for the purposes of the Institution.

Madame de la Batut is now dead, so that the fund has become transferable to the President, and it will be requisite for him, or some person duly authorized by him, to take the necessary steps to obtain a transfer.

We have had some communication with the solicitor of the lady's family, who writes as follows:

"My client, Mr. La Batut, upon taking out administration to his late mother. Madame La Batut, to whom Lieutenant Colonel Henry Lewis Dickinson, by his will dated 17th July, 1819, gave half of the income of his property, for her life, will be entitled to an apportioned part of such income from the last payment, on the 22d March, 1858, to 10th September, in the same year, which would amount to about £70.

"The property originally consisted of French 5 per cent. rentes, payable 22d March and 22d September, but by order of the court a sum of £5,015 three per cent. consols was invested in the name of the accountant general in this suit, to the separate account of Mary Ann de la Batut, the annuitant, to meet the payments of the life income. By the law of France, the life income is apportionable and payable up to the time of death, and Lieutenant Colonel Dickinson having been domiciled in France at the time of his death, that law will apply to this case.

"Will you be good enough, under these circumstances, to obtain the consent of your client in presenting a petition as to the £5,015 and the arrears of dividends due thereon, to ask for the payment to my client of the apportioned sum out of such arrears, without obliging him to go to the expense of proving the law of France upon this subject. I will hand you the necessary proof of death, the expense of which can be included in the necessary costs of the application."

We should recommend that the request contained in this letter be complied with.

We have the honor to be, sir, your most obedient servants,

FLADGATE, CLARKE & FINCH.

To the SMITHSONIAN INSTITUTION,
Washington, U. S.

40 CRAVEN STREET, STRAND,
London, W. C., October 26, 1861.

SIR: Your letter of the 14th August reached us in the long vacation which has just terminated, and we hasten to reply to it.

All that will be requisite to be done in the first instance is, that we should have the authority of the President of the United States to present a petition for an order to have the fund paid to him. On our obtaining this order, a power of attorney will be sent out to the President authorizing some person here to receive from the court of chancery, and transmit to him, or to the managers of the Smithsonian Institution, the fund in question.

Having in the suit had the honor of acting for the President, it might be within our functions to present the petition even without an express authority, but we did not deem it right to do so without some communication with the President or with the managers of the Institution.

Of course, although the order might be obtained without, the fund can only be dealt with on the signature of the President.

We have the honor to be, sir, your very obedient servants,

FLADGATE, CLARKE & FINCH.

JOSEPH HENRY, Esq.,
Smithsonian Institution, Washington.

On motion of Mr. Trumbull, it was

Resolved, That the Secretary and Executive Committee consult with the President of the United States and take such action as may be necessary for obtaining the money referred to in the communication from the solicitors in London.

The Secretary stated that Congress had passed a joint resolution granting to the Institution a set of the volumes of the United States Exploring Expedition.

The Secretary gave an account of the organization of the "Establishment," and stated that although he had regularly given notice to the members, no meetings had lately been held.

The Secretary presented the manuscripts, maps and collections of the expedition to the Arctic regions of Dr. I. I. Hayes, which were referred to Professor Bache.

The Secretary made a statement relative to the system of international exchange conducted by the Institution, and presented the following letter:

HAMBURG AMERICAN PACKET COMPANY,
New York, October 21, 1861.

DEAR SIR: In reply to your favor of October 18, we beg to state that we shall be most happy to accommodate the Smithsonian Institution in furthering the wishes you express, and take on freight, free of charge, any packages which you desire to ship, be they specimens of

natural history, books, or other articles desired to be forwarded to Germany or the continent of Europe, irrespective of bulk.

Very respectfully, yours,

KUNHARDT & CO.

On motion of Mr. McPherson, it was

Resolved, That the thanks of the Board of Regents be presented to the "Hamburg American Packet Company," for their liberal co-operation in assisting to advance the objects of this Institution.

The following letters were presented by the Secretary as illustrations of the *correspondence* of the Institution:

CHATEAU OF ECLIPENDS,
Canton de Vaud, *Switzerland*, *January* 17, 1861.

SIR: I beg you to express to the Institution of which you are the Secretary my sincere thanks for the remittance which you have just made me of three volumes of your reports, (Annual Reports of the Board of Regents of the Smithsonian Institution, 1856, 1857, 1858.) The learned memoirs contained in these volumes possess great interest for me, and I am happy to testify my sense of your kindness.

Together with this letter I have forwarded to Dr. Flügel, at Leipsic, five copies of a volume, which I have but just published, on the "Lacustrian Habitations of Ancient and Modern Times," (XVII plates, 380 figures.) I would ask the favor of you to accept a copy for the Smithsonian Institution, as a slight testimony of my high appreciation. As regards the other four copies, you will confer a sensible obligation on me if you will present them, in my name, to such scientific societies of the United States as you may deem most interested in researches of this kind.

I have had the satisfaction of sending you heretofore some communications on the lacustrian habitations of Switzerland. Since then these researches have been prosecuted with success, and we are beginning to make discoveries of remains of the same kind in Wales, Germany, Scotland, and elsewhere. Africa, Asia, and Oceanica present similar constructions. The floating gardens of Mexico are referable to the same usages, and it would appear to me that you must have in your own lakes remains similar to those of Switzerland. It has seemed to me important that the discoveries of this kind made in Europe should be grouped together in one work, with the historical results which may be deduced from them. You will readily perceive, at the same time, that it is not the history of the race which is alone concerned in these inquiries, but that the natural sciences have also an important interest in them. I would venture, then, to recommend to your favorable attention and to that of your honorable colleagues a labor whose interest is by no means confined to the boundaries of Switzerland.

Be pleased, sir, to accept the assurance of my high esteem and entire consideration.

FRED. TROYON.

To the SECRETARY OF THE SMITHSONIAN INSTITUTION.

LAUSANNE, *January* 7, 1862.

SIR: I have to acknowledge the receipt of your letter dated July 18, 1861, and of a copy of my paper on *archæology*, which has appeared translated in the Institution's report to Congress printed in 1861. It is a great honor which has thus been conferred on my little tract, and I hereby express my sincere thanks for the favor. The translation is, as you remark, rather literal, but it is wonderfully correct, as far as the sense is concerned, and this is the capital point. In due course of time I hope to publish some more papers on the same subject, and I shall not fail to communicate them to the Institution.

The United States are at present going through a crisis which, for the moment, cannot be favorable to scientific pursuits. Let us hope that Providence will so lead matters that the final result shall turn in favor of the great and noble cause of liberty and of progress. Switzerland has seen sad times of intestine discord and of ferment from 1830 to 1847, when a short but decisive civil war settled the question, and now we are enjoying a state of prosperity such as we never knew before. May a similar fate await your own country.

As you mention that some more copies of my paper might be sent to me, I take the liberty of letting you know that they would be very acceptable.

Believe me, sir, to be yours, very respectfully,

A. MORLOT.

The SECRETARY OF THE SMITHSONIAN INSTITUTION.

ST. PAUL, *Minnesota, August* 13, 1861.

SIR: A friend of mine, Mr. Byron M. Smith, tells me that on the occasion of a short sojourn in Washington last winter he paid a visit to the Smithsonian Institution, and, amongst other things, understood that there was in preparation, under your authority, a general map of the aboriginal or other earthworks of North America.

As this is a subject in which I have always taken a great interest, I shall be pleased to assist in the compilation of such a map. If I can be informed by the draughtsman, of the *scale* intended, I will forward a correct geographical outline of the country between Lake Superior (west end of) and the Missouri river. On a map sent to-day by mail, I have marked in red the localities of such groups of *small mounds* as exist to my knowledge. Although these works are utterly insignificant when compared with those of Ohio and Wisconsin, yet a knowledge of their exact localities may be useful in connexion with inquiries in reference to the movements and history of the modern tribes.

Respectfully, sir, your obedient servant,

ALFRED J. HILL.

Prof. JOSEPH HENRY,
Washington, D. C.

ROYAL ACADEMY OF MORAL AND POLITICAL
SCIENCE OF MADRID, *Madrid*, *July* 16, 1861.

This Royal Academy, being impressed with the fact that nothing contributes more efficiently to the advancement and propagation of moral and political science than a frequent communication with persons devoted to its cultivation, has resolved to invite to a reciprocal correspondence all the principal learned bodies, whether national or foreign, whose studies or investigations are analogous to those of this Institute.

As this Academy is the most modern it is proper that it should propose the commerce of the ideas and theories necessary to the progress of moral and political science. And it does not hesitate an instant in sending to your Institution the account of its own commencement and organization, as well as the publications that have marked its short life.

The credit which your Institution has acquired for taking so much interest in all that favors the advancement of civilization and improvement of the people, inspires the Academy of Madrid with confidence that its wishes will be accomplished, and that the illustrious body to which it directs itself to-day will honor it with its correspondence, and accept the exchange of memorials or other works which have been or will be published in future.

MANUEL GARCIA,
Acting President.

By order of the Academy.

PEDRO GOMEZ DE LA SERRA,
Secretary.

The SMITHSONIAN INSTITUTION.

MEXICAN SOCIETY OF GEOGRAPHY AND STATISTICS,
Mexico, *February* 13, 1862.

DEAR SIR: After some delay this society has received your letter and the accompanying books.

The society desires me to return sincere thanks, and to say that it fully appreciates the generous offer that you make in the name of your Institution.

Our society accepts your propositions. It will soon send, in the manner that you suggest, some of its literary and scientific productions, and also those of the other learned bodies whose works you ask for. It will also take care to put in the hands of the agent you refer to, all the periodical publications as they appear.

With the highest consideration, &c., I remain,

D. V. GUADALOUPE.

The SECRETARY OF THE SMITHSONIAN INSTITUTION.

KOENIGSBERG, *November* 23, 1861.

SIR: I have the honor to apprise you of my return from England, and the result of my labors in the interest of the Smithsonian Institution; but I must first tender my thanks for having been enabled to pursue the study of American Neuroptera, to be found in English collections or described by English entomologists.

I must say that my harvest was pretty good, for in most cases I was able to remove the doubts left in my preceding work. In the collections of the British Museum, especially, I found the types of species I did not know, and some also in the collection of Mr. Westwood, at Oxford, and Mr. Saunders, in London. I hope that with these new species, received after having sent my manuscript to Washington, I can make a tolerably large supplement. But the extent of this supplement and the comparison of species already described by me will require considerable time. I therefore believe it will be more convenient to have my work published as soon as printed, and to give afterwards the novelties and corrections in a separate supplement, which will probably make a pamphlet of about eight to ten sheets. You may rest assured, sir, that I shall endeavor to perform this labor as soon and as well as possible; but since I cannot always dispose of my time, I fear, considering the extent of the labor, that it cannot be done before six months.

I find that the translation, the first eighteen sheets of which I have seen, is of perfect accuracy. Unfortunately the work itself leaves much to be desired. I must, however, consider it a consolation that for a first attempt I have attained so much, and that my work may serve as assistance to further and more fruitful researches of the entomologists of your country. I would be gratified if my, so imperfect, labor should call forth numerous rectifications and augmentations from American naturalists. At any rate the interest for the advancement of science will always urge me on to make the synopsis better and better.

I have the honor to remain your devoted,

H. HAGEN.

Prof. HENRY, &c., &c.

[The following letter is given as an illustration of a number of a similar character received relative to the distribution of specimens :]

HAMILTON COLLEGE, N. Y., *February* 1, 1862.

DEAR SIR: I presume the president of our college has officially acknowledged the receipt of the box of shells sent us last month from the Smithsonian Institution. We consider this donation a valuable addition to our collection, and our local papers have given very favorable notices of it. When we arrange the shells in our cabinet we intend to have printed on each ticket "From the Smithsonian Institution."

We shall be glad to receive any other objects of natural history of which you have duplicates to spare. *Skins of birds, &c.*, *botanical specimens*, *fossils*, and *minerals* will be acceptable; also, relics of our Indian tribes. We have a good collection of Indian antiquities mainly derived from the ancient seats of the Iroquois, and we should like to improve our collection by adding specimens from the western Indians.

Yours, respectfully, &c.,

O. ROOT.

Prof. JOSEPH HENRY.

OTTAWA, CANADA, *March* 10, 1862.

MY DEAR SIR: I have to-day received your valuable donation of books, for which I beg to return my most sincere thanks both to you and also to the Institution you so ably represent. They are, indeed, a most valuable addition to my small stock, and are all the more so from the fact that they were totally unexpected.

A great debt of gratitude is due by the world at large to the munificent founder as well as to the enlightened gentlemen that control the Smithsonian Institution, for the great service rendered to the cause of science by the distribution of such works as those you sent me. How many thousands are there who, although they have an earnest desire for scientific and useful knowledge, are, for the want of such works as these, unable to obtain it? As one of these allow me again to tender my most grateful thanks for your kindness.

Believe me, dear sir, yours, respectfully,

J. ARTHUR CODD.

Prof. JOSEPH HENRY,
Smithsonian Institution, Washington.

NEW HAVEN, *March* 27, 1862.

MY DEAR SIR: I have only time to make a few suggestions in reference to your letter.

It is very difficult to make out a list of mineral species at present. The most trustworthy authorities on the subject are Haidenjer, Kennjott, and Rammelsberg.

I think that the names, consisting of a single word, should be adopted. Where this was bestowed by the discoverer (author) of the species, I think his name should follow in small capitals; but in italics only, provided he merely changed the name from a chemical one, or a long, inconvenient compound designation, to a single one.

The well-settled species might be given in rather large capitals; those which are less settled, but at the same time probable, in smaller capitals, while the rest may appear in small type.

I object to the plan of pasting printed or even written names on specimens. It is nowhere followed in the great collections abroad. It might answer in the case of large rock specimens and fossils, but all mineralogists would exclaim against it upon choice specimens, many of which, as the single crystals, would be concealed by the

application. Indeed they very rarely use printed names at all, but instead employ elegantly written cards, each label costing about 12 or 15 cents. It would certainly confer an advantage upon our public cabinets if you would strike off sets of labels of all the important species upon thick card-paper, which might, as required, have the localities inserted with the pen. This would give uniformity to our museums, and prove extremely useful.

I would suggest that before distributing your duplicates, you retain them for six months in order to permit exchanges for things needed by your collection; such exchanges to be made at Washington. Afterwards the duplicates should be given to each of the States.

I shall be very happy to form an exchange of meteoric specimens, in order to obtain a supply of your St. Rosa (New Mexico) iron.

I am very glad you intend to bring the minerals into order. Many valuable contributions will thus be secured.

Excuse the haste in which I write, and believe me, very truly, yours,

C. A. SHEPARD.

Professor HENRY.

UNIVERSITY COLLEGE, TORONTO, *January* 31, 1862.

DEAR SIR: At the request of the faculty, students, and board of curators of Knox College, the theological institution of the Canada Presbyterian church, I have ventured to write to you on the subject of our museum.

We are anxious, by an energetic and united effort, to accomplish three things.

1. To awaken throughout the country an interest in the world of nature.

2. To collect, as far as possible, specimens illustrative of all the zoological, botanical, and mineralogical species of Canada. We think that the solution of several important scientific problems—the northern limit of species, &c.—are involved in this. The ground is being gradually occupied. The Geological Survey, the Botanical Society, the Montreal Natural History Society, the Canadian Institute, &c., are all doing their share in the work of research; but there is a wide field still open.

Our third object will be to supply societies, museums, &c., with specimens from this country. In doing this we shall always bear in mind the fact that the Smithsonian is the great central institution for the continent, and that in no other way can our ultimate object be so well attained as by working with you.

A part of our scheme was to issue circulars giving information on the best methods of procuring, preserving, and forwarding specimens.

Could you furnish us with three hundred copies of your "Directions?" We will, with your permission, append a short circular stating our plan, and appealing to the people to join with us in carrying it into execution, and then without delay try to put them all into the hands of parties who will make a good use of them. Please aid us all you can in the matter. We have just enough of articles on

hand to form the nucleus of a good museum; for the rest we look to the future—to your kindness and to the blessing of nature's God on our exertions. If you can spare the pamphlets we will gladly remit whatever you value them at.

Thanking you most earnestly, dear sir, for the reports and catalogues, I have the honor to be, yours, very truly,

JAMES HUBBERT,
Secretary Board of Curators, Knox College Museum.

Prof. JOSEPH HENRY, LL. D.,
Secretary Smithsonian Institution.

ROYAL HORTICULTURAL SOCIETY,
South Kensington, W., December 21, 1861.

DEAR SIR: I am requested by the Secretary, while acknowledging the receipt of your letter of October 18th, to acquaint you that the council have much pleasure in acceding to the request that this society's journals should be sent to the various institutions therein named, with a view to interchange. A parcel will therefore be sent to Mr. Wesley in a few days for transmission to you.

I am, dear sir, yours faithfully,

HENRY J. DOWDEN.

JOSEPH HENRY, Esq., *Washington.*

COBOURG, CANADA WEST, *April* 1, 1862.

MY DEAR SIR: I take this opportunity for expressing my warmest thanks for your repeated kindness in furnishing me with so many valuable publications on the insects of this continent, without the aid of which my progress in the study of entomology would oe but slow and difficult. I can speak for others in this country, as well as for myself, when I say that we are deeply grateful for the assistance we have received from your noble Institution; and that but for its liberality the natural sciences would have hardly made what advancement they have in this country during the past few years.

I shall be only too glad to reciprocate your kindness to the best of my ability by furthering the objects of the Institution in any way that lies in my power.

I remain, my dear sir, very gratefully yours,

CHARLES J. BETHUNE.

Professor JOSEPH HENRY, LL. D.,
Secretary to the Smithsonian Institution.

HONOLULU, SANDWICH ISLANDS,
February 10, 1862.

DEAR SIR: I am in receipt of your favor granting me a suite of the duplicates of the shells of the northwest coast of America in the hands of Mr. Carpenter.

I had, a short time previous to the arrival of your letter, forwarded to the Institution a package containing shells and rare crustacea, not included in my remittance to you two or three years since.

It is my intention to supply you a full suite of the mollusca of our islands, including typical specimens of those described by myself, and also one to Mr. Cumings, of London, whose collection I learn from Dr. Gray will be eventually added to the British Museum.

I venture to ask of you an addition to my library, of the Reports of the Smithsonian Institution. I have purchased the "Contributions to Knowledge," but the Reports are not on our islands. One in particular I am wanting, which I learn contains a catalogue of transactions or proceedings of scientific societies; also a few copies, say half a dozen, of the Check List of the shells of North America, published by the Institution. Should you be pleased to furnish me the above, be so good as to forward them to Bailliere Brothers, New York city, who send me a box of books every few months.

I have been attempting to invent a simple apparatus for the measurement of the tides at our islands, but do not succeed very well. Natives cannot be depended on for watching any such instrument. It should be self-registering. I am satisfied that a register of winds should be kept in connexion with it, and perhaps also a barometrical one. If you take any interest in such researches I would be pleased to hear from you in regard to them as to assistance or advice.

I remain yours truly,

W. H. PEASE.

Professor JOSEPH HENRY,
Smithsonian Institution.

[NOTE.—Dr. Bache, of the Coast Survey, has lent Mr. Pease a tide-gauge on the responsibility of this Institution.]

CIRCULAR OF THE INSTITUTE OF RUPERT'S LAND,
Assiniboia, February, 1862.

We announce this institute to the public, knowing our many disadvantages, but still with a lively hope that our labors will be rewarded with some good results. Our numbers are small; but we have among us many who will devote the greater part of their time to collecting and observing, and these, with their admirable opportunities, cannot fail to accomplish much good work. Already we have the nucleus of a library. Specimens are coming in faster than we can take care of them. Necessaries for collecting and observing are being distributed and communications have been received.

We will shortly be presented with £150, by the friends and admirers of Sir George Simpson, for the purchase of a "Simpson" Telescope, and £60 from the friends of the late much esteemed Dr. Bunn, for the purchase of achromatic microscopes. And now, with this commencement, we feel the right, and do ask for countenance and assistance from scientific men and societies in all countries, promising, in return, all that energy and zeal can do in the cause of science.

A prospectus accompanies this circular, giving all the necessary information, and we would ask communications from all to whom those

are sent, with any requests, observations, or information by which we may benefit them, or they us.

WILLIAM MACTAVISH,
JOHN SCHULTZ,
Secretaries.

The SMITHSONIAN INSTITUTION.

WASHINGTON, D. C., *March* 27, 1862.

SIR: In compliance with your suggestion, I beg to set before you a few facts respecting Liberia College, in the republic of Liberia, West Africa.

1. The college is the offspring of the benevolence of citizens of Massachusetts who, in 1850, organized themselves into an association for educational purposes in Liberia, with the title of "Trustees of Donation for Education in Liberia," and an act of incorporation was obtained the same year from the legislature of Massachusetts.

2. Their sympathy and exertions have been so generously seconded that the trustees have been enabled to erect a capacious and substantial building on the heights of Monserrada, in the city of Monrovia, the capital of the republic. The college building is three stories in height, with piazzas surrounding it; with dormitories capable of accommodating between thirty and forty students, apartments for two professors and their families, lecture and dining rooms, chapel, &c. This building, the material of which is brick, cost nigh $30,000, and is now finished. The college building has been presented, as a gift, to the republic of Liberia, for a *national institution*, and is to be governed by a body of Liberian trustees, nominated by the President of the republic, and elected by the senate.

3. Besides the above expenditure, that is for the building, the "Trustees of Donations," &c., have, under their own control, at interest, an endowment of about $30,000, and a sum of about $40,000 has been left in legacies, for the purposes of Liberian education, and is under the control of other colonization societies, which will, without doubt, be ultimately appropriated to the ends of the Liberia College. A further sum of $50,000 is promised for the Liberia College by the several members of an eminent family in New York, in lieu of a like sum left by their father on his decease, for the college, but which was lost by a legal decision.

4. Liberal donations of minerals and large gifts of books have been made to the college, both by distinguished individuals in this country and by Harvard and Yale Colleges.

A faculty has already been elected; two of its professors inaugurated; and the college has already, this year, commenced operations.

The undersigned, authorized by the *American* trustees for the purpose, respectfully requests the addition of the publications of the Smithsonian Institution to the collections already made for the Liberia College.

I am, sir, your obedient servant,

ALEX. CRUMMELL.

Prof. HENRY.

RECOMMENDATION OF SHEA'S INDIAN LINGUISTICS, REFERRED TO IN THE SECRETARY'S REPORT.

We recommend Mr. Shea's series of grammars and dictionaries of the Indian languages to the attention of the Smithsonian Institution, and think that a subscription which will insure the continuance of the series will be eminently within the scope of the foundation, by preserving a number of rapidly perishing monuments of human knowledge, and securing to posterity, in the languages of the native tribes, the surest clue to their origin and affinities.

E. B. O'CALLAGHAN.
JNO. V. L. PRUYN.
S. B. WOOLWORTH.
JARED SPARKS.
GEORGE LIVERMORE.
GEORGE H. MOORE.
GEORGE W. RIGGS, JR.
PETER FORCE.
GEORGE GIBBS.

MR. SHEA'S ACCOUNT OF HIS LIBRARY OF AMERICAN LINGUISTICS.

With the increasing interest felt in the science of ethnology, much attention has of late been given to the study of the languages of the aboriginal tribes of America, and it must be confessed that more philosophical research, talent, and investigation have been bestowed upon them in Germany than in our own country. Yet the science is still in its infancy. Relying on crude or hastily taken vocabularies, which often confound different languages, many have set on foot theories, and entered into criticisms, which fall to the ground on the examination of a carefully prepared grammar or dictionary of the language. Fortunately, of very many American languages such works exist, often the labor of early missionaries, whom a long residence with a tribe, a knowledge of their habits, manners, and usages, enabled to write with accuracy and judgment.

Very few of these works were printed. Most have remained in manuscript, and are liable to perish by accident. Every investigator knows that many which survived till a few years since are now irrecoverably lost.

The language of a tribe is its most important relic. The mechanical arts were rude, and the remains so scanty, that mound and bone pit, and deserted village, have given us scarce a clue to the history of the peoples to whom they belonged. But language is the great key to the affinities of the tribes, and often enables us to trace their migrations, and in all cases to determine their kindred.

We owe it to posterity to allow the work of destruction to go no further, and to put in a permanent form every work now in manuscript, giving the grammatical structure or a full vocabulary of an Indian dialect. Our national honor is interested, and the learned abroad even now begin to wonder at our indifference.

Impelled by a desire to save these works, I began a series of them, printing a few copies of each, from the original manuscripts, my object being to preserve them; and six grammars or dictionaries of dif-

ferent tribes have already been issued. So much, however, is yet to be done, that I appeal to the public libraries, the historical societies, and literary institutions of the country, as well as to ethnologists, here and abroad, to aid me, by subscribing to the series, as the greater the number of subscribers, the lower the works can be afforded, and the greater the number of volumes that can be issued.

The works are handsomely printed on good paper, and carefully edited, forming a series of royal 8vo. volumes creditable to any collection.

NOW READY.

1. A French Onondaga Dictionary. From a manuscript of the seventeenth century	$4 00
2. A Grammar of the Selish, or Flathead Language. By Rev. G. MENGARINI	4 00
3. A Grammar of the Heve (Sonora) Language. Edited from a manuscript of the seventeenth century. By B. SMITH, Esq.	1 00
4. A Grammar of the Mutsun(California) Language. By F. FELIPE ARROYO DE LA CUESTA	2 50
5. A Grammar of the Nevome (Pima) Language. Edited from a manuscript of the seventeenth century	4 00
6. A Grammar of the Yakama Language. By the Rev. M. C. PANDOSY	2 50

IN IMMEDIATE PREPARATION.

7. A Vocabulary of the Sextapay (California) Language. By PADRE B. SITJAR.
8. Vocabularies. Collected by the late W. W. TURNER.
9. Maillard's Grammar of the Micmac Language.
10. Arroyo's Vocabulary of the Mutsun.
11. Potier's Radical Words of the Huron Language.
12. Bruyas' Radical Words of the Mohawk Language.
13. A French-Illinois Dictionary.
14. Potier's Huron Grammar.
15. Lefevre's Vocabulary of the Montagnais Language.
16. Bruyas' French-Mohawk Dictionary.

Various others will be added, and, if encouragement is given, the series will include an English translation of Molina's "Mexican Dictionary."

JOHN G. SHEA,
83 *Centre street, New York.*

The volumes of the series may be ordered of Trübner & Co, London; Charles Reinwald, Paris; B. Hermann, Leipzig.

The Board of Regents, having examined the library, collections, museum, &c., adjourned *sine die.*

EULOGY

OF

CORNELIUS CONWAY FELTON, LL. D., &C.,

ONE OF THE REGENTS OF THE

SMITHSONIAN INSTITUTION.

PREPARED AT THE REQUEST OF THE BOARD, BY THEODORE D. WOOLSEY, LL.D., PRESIDENT OF YALE COLLEGE.

At a meeting of the Board of Regents of the Smithsonian Institution, held May 1, 1862, Professor Henry, the Secretary, having announced the death of Dr. Felton, one of the Regents, Professor Bache made a few appropriate remarks, and offered the following resolutions, which were unanimously adopted:

Resolved, That the Board of Regents of the Smithsonian Institution deeply mourn the loss of their fellow Regent, CORNELIUS CONWAY FELTON, the distinguished President of Harvard University, whose profound learning and ready use of the rich stores of ancient and modern lore excited general admiration, while his genial temper, affectionate disposition, and open manners, endeared him as a friend to every member of this establishment.

Resolved, That in the death of President Felton, our country, in the hour of its trial, has lost a wise and influential citizen, our government a warm and eloquent supporter, Harvard University a learned and efficient head, and this institution an active and valued Regent.

Resolved, That we sincerely condole with the bereaved family of President Felton, and offer to them our heartfelt sympathy in their deep affliction.

Resolved, That Dr. Woolsey be requested to prepare a suitable notice of President Felton, to be inserted in the journal of the Board of Regents.

Resolved, That a copy of these resolutions be communicated by the Secretary of the Smithsonian Institution to the family of the deceased, and to the faculty and corporation of Harvard.

EULOGY.

The duty has been laid upon me of preparing a brief tribute to the memory of Cornelius C. Felton, late a Regent of the Smithsonian Institution. I undertake this office the more readily, because a friendly and most pleasant acquaintance of nearly thirty years standing, cemented by common pursuits and unbroken by any of those jealousies which sometimes divide men of the same literary calling, has

enabled me to form a definite opinion of the worth and services of one whose death the country, in common with Massachusetts and with Harvard University, deplores.

Cornelius Conway Felton, the son of worthy but by no means opulent parents, was born at West Newbury, Massachusetts, November 6, 1807. The first decided impulse in the direction of scholarship and of a taste for letters was given to him by Simeon Putnam, who kept a private school at North Andover, with whom he remained as a pupil a year and three months. In this year and a quarter prior to his entrance into college, Putnam awakened so great an enthusiasm in the mind of his pupil that the latter, according to a statement in manuscript drawn up by one of his friends, "read Sallust four times, Cicero's Orations four times, Virgil six times, Dalxel's Græca Minora five or six times, and the poetry of it till he could repeat nearly all of it from memory, the Annals and History of Tacitus, Justin, Cornelius Nepos, the Anabasis of Xenophon, four books of Robinson's Selections from the Iliad, the Greek Testament four times, besides writing a translation of one of the Gospels, and writing a translation of the whole of Grotius de Veritate, which he brought in manuscript to college; also he wrote a volume of about three hundred pages of Latin exercises, and one of about two hundred pages of Greek exercises, and studied carefully all the mathematics and geography requisite to enter college." That the severe study necessary in order to do all this in so short a time might be detrimental to his health will be readily believed. He suffered from these overstrained efforts during his residence in college and afterward. Still he continued his course of earnest study through his college life, devoting a good deal of spare time to extra Greek, and forming an acquaintance with several of the modern languages and with the Hebrew. Besides which he contributed to his own support in several ways, especially by keeping school during parts of his sophomore and junior years, and in the latter year by teaching mathematics for six months in the Round-hill school at Northampton, under Messrs. Cogswell and Bancroft. He was prepared, by this introduction into the art of teaching and by his excellent scholarship, for the employment in which he was engaged for two years from the time of his graduation—the charge of a high school at Geneseo, New York, which he undertook in company with two of his classmates. From Geneseo he was called back, in 1829, to his Alma Mater to fill the office of Latin tutor, from which department he was transferred the next year to the Greek. His election to the chair of college professor in 1832 showed the estimation in which he was held by the authorities of the University. On the resignation of Dr. Popkin in 1833, who had the chair of Greek literature upon the Eliot foundation, Mr. Felton was appointed his successor, and continued in this professorship until his elevation to the presidency in 1860. Thus thirty years of his life were spent in cultivating and teaching Greek letters.

As a Greek scholar, he was not surpassed for breadth and accuracy by any other in the land. His nature was many-sided, and he strove after complete scholarship both in what pertained to the language

and in what pertained to all the branches of the literature of the Hellenic race. Yet, like every other scholar, he had his favorite departments of pursuit, while other sides of it had less attraction for him. To linguistics and general philology and to the verbal side of Greek learning he was not so much drawn as to all the manifestation of the Greek mind and life. Here again it was Athens in her palmiest days; it was her unrivalled dramatic poets, and especially that prince of the ancient comedy, who disclosed to us the life of Athens at the pinnacle of her renown, and when she was sliding down from her eminence—it was this age and these monuments of Greece which had the greatest charms for him. The spirit of Aristophanes lodged in Professor Felton; he had the same sense of the ludicrous, the same keen judgment of character, the same underlying earnestness of patriotism, the same political conservatism.

A mind which had such a strong relish for exhibitions of life in the concrete forms would be apt to convey pleasant and profitable instruction. Professor Felton seems to have been a very genial instructor, clear in his conceptions and explanations, sufficiently strict in grammatical analyses and in keeping his pupils to their tasks, and yet relieving the tedium of the recitation room by lively illustrations of the author read, so that the lesson was not more a task than a pleasure, enriching and beautifying everything by reference to ancient art, as well as by a pure manly taste which went along with its whole scholarship.

This æsthetical power of his mind deserves a more distinct mention. He had within him a love of art, and his judgment, natively sound, was improved by devotion to a language and a literature which cultivate the taste more than any other. To him, therefore, the life of Greece consisted not solely in its poets, orators, historians, and philosophers, but in the euphonies of its words, in the rythm of its periods, in its wondrously exquisite and varied poetical metres, in its simple but grand architecture, in those works of its sculptors and founders which immortalized over again the materials of a literature already immortal.

Here we may add that he had two opportunities of inspecting the monuments of Greek art, and of visiting that land where so many of his thoughts had dwelt. In 1853 and the following year he devoted five months of a European tour to Greece, ancient and modern, to her present life and the remains of her past glory; and again in 1858 he spent part of another summer in the same land. Whatever reminded of ancient days and enabled him to conceive more clearly and understand more fully the meaning of the ancient writers, together with those reliques of art which time and barbarism have spared—this naturally claimed his attention first; but he sympathized also with the free, hopeful, restored Greece of the present; he examined the workings of her political institutions, visited the halls of legislation at the capital, formed an acquaintance with the learned men who adorn the University of Athens, and returned in the faith that modern Greece has a noble destiny before her. He was led by his tours to connect the Greek and the Romaic languages more closely together, to urge the importance of studying the latter, and to advocate the application

of the modern pronunciation to the literature of the ancient tongue. Not long after his return from his first journey, in the year 1856, he published selections from modern Greek writers, accompanied with explanatory notes, and a little earlier enriched an American edition of Smith's "History of Greece" with a preface, notes, and a continuation of Greek History from the Roman conquest until the present time.

While engaged in the daily duties of a laborious profession, Mr. Felton found leisure to prepare for the press a number of editions of Greek authors and other works within the same department. His maiden work of this kind was an edition of Homer's Iliad, published in 1833, with English notes—which were carefully revised and enlarged in subsequent editions—and with the addition of Flaxman's illustrations. Next, in 1840, he sent forth from the press a Greek reader, containing selections from writers of the best stamp—a work which has been repeatedly printed, and has mantained its ground among the principal introductions to the study of that language. This was followed in the next year by an edition of the Clouds of Aristophanes, with an introduction and a commentary, which appeared again in a revised form and was republished in England. In 1843, in conjunction with Professor Edwards, of Andover, and Professor Sears, then of the Baptist Theological Seminary at Newton, he published a work entitled Classical Studies, consisting principally of translations from the German, his contributions being selections from the works of Frederic Jacobs. In 1844 he rendered a valuable service to classical literature by translating, in conjunction with Professor Beck, Munk's Treatise on Greek and Roman Metres. Three years afterward appeared his editions of the Panegyricus of Isocrates —that much polished closet-oration of the "old man eloquent," and of the Agamemnon of Æschylus—that difficult chef-d'œuvre of the earliest dramatist. Both of these passed into second editions. In 1849 he brought out an edition of the Birds of Aristophanes, and in 1852 "Selections from Greek Historians," namely, from Herodotus, Thucydides, Xenophon, Polybius, Diodorus Siculus, Arrian, and Pausanias. In the course of the same year appeared a tribute from his pen to the memory of his immediate predecessor in the Eliot professorship, entitled "Selections from the Writings of Dr. Popkin, with a Biographical Sketch."

These were his principal contributions through the press and bearing his own name, to the main study of his life. But we ought not to pass over his frequent lectures and anonymous writings, tending to illustrate and recommend Greek learning, such as his four courses of Lowell Lectures, and his frequent contributions to the *North American Review.*

Nor ought the briefest sketch of Mr. Felton's life to omit his literary labors beyond his own immediate province. As his mind strove to grasp universal knowledge, and as he maintained a lively sympathy with the literature of most of the cultivated nations, so, from time to time, he poured forth through the press the gatherings of his rich and many-sided mind. Among his original works we mention his

"Life of General Eaton," in the ninth volume of the first series of Sparks's "American Biographies;" his biographical notices accompanying Longfellow's "Poets and Poetry of Europe;" his articles in the *North American*, upwards of fifty, and in the *Christian Examiner*, upwards of twenty-five in number; his contributions to the *New American Encyclopædia*,* and others less elaborate in the daily journals. If with these we take into view the help which he lent in various ways to education and science, as one of the Massachusetts Board of Education, as one of the school committee for the town of Cambridge, and as Regent of the Smithsonian—to which trust he was elected on the resignation of Mr. Choate, in 1856, and re-elected for the full term of six years in February, 1861—and if we bring into account, also, his labors for a number of years in the office of Regent in Harvard University, and that at the same time he gave instructions in a school under the charge of Professor Agassiz, we shall wonder that one man, besides the duties of a very laborious professorship, was able to do so much, and perhaps wonder still more that he did it all so easily to himself and so well. It is rare, we imagine, to find a life of so much faithful, patient industry united to a temper so genial and social as his, so capable of finding entertainment and recreation on every side.

The services of such an academical officer could not fail to be prized and honored. Years before his election to the presidency of Harvard, his name was prominent among those who were thought of for that post; and when President Walker felt compelled by ill-health to retire from the station which he had filled so wisely and satisfactorily, the voice of the public anticipated the votes of the boards which constituted Prof. Felton his successor. He was inaugurated into his new office July the 19th, 1860, and those who heard his address pronounced upon that occasion, if they had not known the man before, must have felt assured that his administration would be firm and vigorous. The distinct opinion which he there avows, that no offences against civil order can be tolerated in a college which would not be borne in the wider circles of citizens—that academical walls can furnish no refuge for crimes, nor academical relations justify outrages on gentlemanly propriety, or on the feelings of fellow-students, was one which commends itself to all who are acquainted with our higher institutions of learning, and which, if united in the carrying of it out with such kindliness as was manifest in the character of President Felton, would strengthen and secure everything that is good in a college life. Whatever temporary obstacle or local custom, "more honored in the breach than in the observance," might oppose for a time, it is certain that the claims of law and order would at length prevail, and the state of things afterwards become so much the better.

President Felton entered thus into his new duties, with the confidence of the wisest and best on his side, and gave himself up chiefly

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* Some of these were on Agassiz, Athens, Attica, Demosthenes, Euripides, and Homer.

to administrative functions, not without deep regrets, we are sure, at leaving those pleasant toils which had filled thirty years of his life. But Divine Providence had scarcely invested him with his new authority when he was summoned away from these earthly responsibilities and labors. A little less than two years of his official life had elapsed when the complaint of which he died—hypertrophy of the heart—showed itself in an aggravated form, after having manifested its presence in his system for some twenty years. He was not, however, so ill at first but that he could undertake a journey, and it was hoped that a change of climate might do him good. Setting out for Washington—where he intended to be present at a meeting of the Regents of the Smithsonian Institution—he had reached the house of his brother in Chester, Pennsylvania, and was seized with an attack of disease during the ensuing night. Here he breathed his last, Wednesday, the 26th of February, 1862. His remains were removed to Cambridge, where a sermon on his death was preached, March the 9th, by Dr. Peabody, Preacher to the University, and appropriate resolutions, in honor of his memory, were passed by the Governing Boards, the Faculties, and others.

We have spoken of President Felton as a scholar and a worker, earnest and successful, in the field where Providence placed him. But the man is far more in the scale than the scholar. Let us then look for a few moments at the man in his traits of mind and character, and in the conduct of life.

His mind, as may have already appeared from what we have said of his scholarship, was a rounded, well-balanced, many-sided one, where no trait was deficient. Yet the predominance of the æsthetic faculty, with the attendant pleasure derived from art and the works of creative intellect, may have given that direction towards scholarship and belles lettres, towards the concrete form rather than the abstract metaphysical principle, which somewhat characterized him. His simple, correct taste, and his judgment, which estimated probabilities aright, and looked below the show and the surface, although, no doubt, cultivated by the study of language, and especially of Greek literature, must have had, beyond question, an independent natural foundation. He had a native curiosity and thirst for knowledge, which felt and grasped on every side; if you wanted to know about Jasmin, the Provençal Burns, he had read his poems, he could speak of the Finnish mythology, and in his later years especially he entered with zeal into the progress of natural science. Nor ought his keen sense of the ludicrous and his humor to be forgotten here, which made him the most entertaining of companions without undermining the manliness of his character. And the easy play of his faculties, working rapidly and smoothly, without jar or much effort, deserves especial notice.

Among the traits of President Felton's character may be mentioned kindness and sympathy, united with moral energy, courage and firmness in acting up to his convictions. His kindly nature showed itself in the forms of sociality, friendliness, and generosity reaching to self-sacrifice. His friendship extended widely beyond the borders

of his way of thinking in religion and politics, and men of various opinions and convictions sought his companionship, and partook of his regards. Few men have had more friends or fewer enemies, and yet he never shrunk from avowing his own principles. He enjoyed society, of which, by his pleasantries and other colloquial powers he was made to be the life. "He was generous," says his friend Professor Peabody, "to the last degree; no income could have made him rich, while there were the needy around him; and of time, more precious than gold, and of the wealth of intellect, he was no less lavish than of the inferior goods, which he prized only as the means of making others happy. The labor of hand and brain, which might have been employed in building up his own fame, was freely given to all who sought it. Many have been the literary works and enterprises with which his name was never connected, which owed a large portion of their merit and success to materials which he furnished, or to his advice, revision, or criticism." And the same friend bears witness to his sympathy with "every noble and generous work for human progress and well being."

If the stranger, after an evening's acquaintance, may have been led by Mr. Felton's companionableness and flow of mirth to regard him as wanting in moral earnestness, such a judgment would be pronounced hasty and superficial by the many grave and good men who gave him their friendship and respect. He by no means lacked any of those qualities which constitute the man of an earnest and dignified life. As has been beautifully said of him, "his force of character, hidden on ordinary occasions by his gentle and sunny temperament, appeared impregnable whenever it was put to the test." He had firm settled convictions and well digested rules of action; he had purposes which could not be shaken by other considerations than those addressed to the reason and conscience; he had a noble, manly courage which could carry him onward in the face of opposition. These qualities, with fidelity, uprightness, and simplicity of character, as displayed in his college duties, and in other relations of life, secured for him the esteem and respect of all.

The union of kindness and firmness with sound judgment and perspicacity made him an excellent college officer. But for his character as a ruler over students we will appeal again to what Dr. Peabody says of him: "I well remember the early years of his official connexion with the college; his fraternal sympathy with the students; his gentle discipline when forbearance was safe and right; his reluctant, yet uniform consent to sterner measures, when the cause of order and virtue demanded them; his tender consideration for those who were struggling as he had struggled, bravely and honorably against adverse circumstances; his readiness to sacrifice his own ease in aid of those who sought to transcend the required measure of study, to furnish facilities for their researches, and to contribute from the funds of his own thought and learning for their growth in knowledge. Such was his course during his entire life as a teacher; and could we number up the youth who have been animated by his example, stimulated by the genial fervor of his enthusiasm, encouraged by his patient and

unselfish devotion to their welfare, and sustained in their worthy ambition after they left these halls by his persistent and effective friendship, we should have a record of quiet, unostentatious beneficence, that would distance and belittle many life-works of world-wide and long-enduring fame."

President Felton was in his feelings and opinions, like the greater part of scholars, a conservative, not without sympathy with forward movements in society, but led by his tastes and acquaintance with the past to look with suspicion on sudden changes in the established order of things. In a similar spirit he showed no mercy towards what he regarded as false pretensions to science. It will not soon be forgotten with what zeal he followed up the spiritualists, putting their claims to the test, driving them from point to point, and exposing what he considered to be intentional fraud. In his political principles he may be described as a conservative whig, a friend and admirer of Daniel Webster. In his religious faith he was a Unitarian: Dr. Peabody characterizes him as "reverent and devout, loving the Word and Ordinances of God, meekly yielding himself to the teaching and leading of the Saviour, strong in the hope that is full of immortality."

He was twice married; the first time in 1838, to Miss Mary Whitney, who died in April, 1845, and again in September, 1846, to Miss Mary L. Cary, who survives him. He has left five children.

Such is a brief sketch of one of the recently deceased regents of the Smithsonian Institution*—a man who, by his industry and vigor of mind, made himself; a man whose genial nature and social qualities created friends for him on every side; a man who to the highest attainments in one department united in an uncommon degree a large and liberal acquaintance with the circle of knowledge; a man of fine tastes, of most kindly sympathies, of strict uprightness; a man who adorned his professorship by the best qualities of a teacher, and the mingled kindness and firmness of a wise disciplinarian, and who brought to the presidential chair of Harvard the firm purpose to raise the standard of that ancient University in everything that was good and noble.

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* President Felton took a lively interest in the Institution, and actively participated in the proceedings of the Board. His communications appearing in the reports of the Board are as follows: In the report for 1857, p. 79, a report on the present of a book from Greece; p. 82, one on the purchase of Stanley's Indian gallery; p. 88, one on Professor Henry's communication relative to the telegraph; and in the report for 1859, p. 104, a eulogy on Professor W. W. Turner, and, p. 106, one on Washington Irving. In addition to which he gave several lectures on Greece, and made a number of confidential reports on communications relative to linguistics, which had been referred to him for examination by the Secretary.

EULOGY

OF

HON. STEPHEN ARNOLD DOUGLAS.

PREPARED AT THE REQUEST OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION, BY HON. SAMUEL S. COX, OF THE HOUSE OF REPRESENTATIVES.

At a meeting of the Board of Regents of the Smithsonian Institution, held May 1, 1862, Professor Henry, the Secretary, having announced the death of Judge Douglas, one of the Regents, the following resolutions were offered by Hon. Lyman Trumbull, and unanimously adopted.

Resolved, That in the death of the Hon. STEPHEN A. DOUGLAS, the Smithsonian Institution has been deprived of a most zealous friend; the Board of Regents of an active and attentive member; and the country of a distinguished and influential citizen.

Resolved, That the Board of Regents deeply sympathize with the bereaved relatives of the deceased, and that a copy of these resolutions be transmitted to them.

Resolved, That the Hon. S. S. Cox be requested to prepare a suitable notice of the Hon. S. A. Douglas, to be inserted in the journal of the Board of Regents.

EULOGY.

In February, 1854, Stephen A. Douglas, of Illinois, while a senator from that State, was appointed one of the Regents of the Smithsonian Institution, and continued a member of the Board until the time of his death, on the morning of the 3d of June, 1861. From the pursuits of his life and the peculiarities of his course, it might be thought that he was not well qualified to discharge properly the duty of a trustee of a fund intended for the increase and diffusion of knowledge among men. But this would be a mistake, for, although he had given no special attention to any branch of science, yet his mind was of that comprehensive cast which enabled him duly to appreciate the nature of the bequest and the general principles of the different plans which had been proposed for carrying it into execution. It is true, as I am informed, that before he was elected a Regent he had adopted the popular idea that the bequest was intended merely to diffuse useful knowledge among the people of the United States; yet when he came to study the precise words of the will of the founder, and caught, as he immediately did, the peculiar idea of the object in-

tended, namely, the extension of the bounds of science, and not merely the teaching of what is already known, he fully adopted the views on which the present organization of the Institution is based, and ever after continued a warm advocate and an able supporter of the measures now in successful operation for the realization of the liberal and enlightened intention of James Smithson.

In accordance with the usage heretofore observed in similar cases, a resolution having been adopted directing the preparation, for the proceedings of the Board of Regents, of a sketch of the characteristics and incidents of his life, and the duty of furnishing this having been assigned to me, I address myself to the task with an earnestness that is only tempered by my fear that I have neither sufficient time nor sufficient ability to do full justice to the memory of one whom I admired as a public man, and sincerely loved as a friend.

It is, indeed, pre-eminently fitting that the name of Douglas, so fondly cherished by the nation, and so familiarly spoken wherever American statesmanship is known, should be honored in the journals of this Institution, for whose prosperity he evinced so earnest a desire. It was not merely as one of its Regents that he showed himself the true and enlightened friend of objects kindred to those of this establishment. He ever advocated measures which served to advance knowledge and promote the progress of humanity. The encouragement of the fine arts, the rewarding of discoverers and inventors, the organization of exploring expeditions, as well as the general diffusion of education, were all objects of his special regard, whether in the councils of his State, or in the hall of the Senate of the Union.

Stephen A. Douglas was born at Brandon, in Vermont, on the 23d of April, 1813. Like many, perhaps I should say like most, of the rural neighborhoods of New England, Brandon contained a highly intelligent and energetic population, independent alike in thought, speech, and the conduct of their public affairs; and doubtless the fact of his early years having been passed under the influence of the daily life and conversation of such neighbors, had some share in imbuing the boy with the sturdy independence and resolute energy which the man was so remarkably and so triumphantly to exhibit throughout his at once brilliant and laborious career.

His ancestors were of Puritan descent; and his father was a physician of both ability and reputation, but died at a prematurely early age, leaving his widow in very straitened circumstances, if not even in actual distress. It may, indeed, be only too reasonably feared that the latter was the case, for, excellent mother as she was known to be, she yet was unable to give young Stephen the full education he so much desired and so well deserved. He attended the district school during only one-third of the year; during all except the four winter months he was engaged in the hard labor of a farm or in the shop of a cabinet-maker. In this alternation of manual labor and imperfect and interrupted schooling he continued till he was twenty years of age, when he migrated to Illinois, where he taught school for his support, while he resolutely studied law. In 1834 he was admitted to the bar, and we may judge of the character of his early efforts in the

courts from the fact that in 1835, being then only twenty-two years of age, this young man, whose short life had been so largely taxed by adverse circumstances, was elected State attorney. From that time he was continually in the public service. He was, in turn, State attorney, member of the legislature, secretary of State, judge of the supreme court of Illinois, and registrar of the land office; and subsequently he was a member of the lower house of Congress, and three times in succession he was elected by his adopted State to be United States Senator; and, as is well known, not long prior to his death he was the very popular though unsuccessful candidate for the highest executive office in the gift of the nation.

These are the prominent points in the career of Douglas, whose life, commencing in obscurity and continuing through nearly the half of its whole duration under the most adverse circumstances, ended in the full light of high position, and the full glow of popular favor. The principles which he advocated, and to which he unwaveringly adhered, as well as the measures he proposed, have been the theme of both criticism and eulogy elsewhere, but the discussion of them here would be out of place, and in violation of a rule early adopted by the Board of Regents, that in the affairs of this Institution partisan politics shall forever be unknown. The points, however, in his personal character which enabled him to obtain so important a position, and gave him so great an influence, not only over intimate friends and colleagues, but also over the public mind, may well claim our attention as a study no less important than interesting.

If continued success be the test of merit, then must all admit that Judge Douglas was no ordinary man. That success in a single effort, which may be referred to a fortunate concurrence of circumstances over which the successful man had no control, is not the true criterion of talent is a truth which must be readily admitted. But when the course of an individual is marked through a series of years by a continual advancement in the same direction, and especially when that advancement requires forecast, knowledge, perseverance, and energy, his success most assuredly *is* evidence of talent, if not of genius.

Courage, energy, and a working power, both mental and physical, which have rarely been surpassed, were the qualities which chiefly served him in his earlier years. The son of a poor widow, and compelled to spend in bodily labor the time which other boys of his age pass in school, he would probably have remained a poor and obscure individual had it not been for the resolute WILL to elevate himself, and the courage, force of character, and determination to ACT in accordance with that will which characterized his whole life. But of itself alone, that seemingly inexhaustible power of labor which obtained for him the suggestive sobriquet of "the little giant" would have been insufficient to effect the great success which he actually achieved, had it not been directed and aided by other mental characteristics, which some even of the warmest admirers and eulogists of the *politician* Douglas seem to me very insufficiently to appreciate.

In addition to the characteristics which I have already attributed to him, Judge Douglas was remarkable for his quick perception of the

nature of events, and of the consequences which, with almost mathematical precision, he could predicate as to their results. He had, to a wonderful degree, the power of seizing on general principles, and of making them a part of his intellectual stores to be referred to in whatever particular case he might have to deal with; and his retentive memory enabled him on the instant to call up alike a general truth, and a host of particular facts in effective illustration of his premises.

These qualities might have been modified, but could not have been increased, or even strengthened, by classical training; nay, in becoming more refined and fastidious, it is far from certain that his mind would not, at the same time, have become less robust, energetic, and bravely self-reliant.

We do not intend by this remark to throw doubt on the importance in general of that early mental discipline which is furnished by the training of the schools, but to present the suggestion that in particular cases of extraordinary native vigor of intellect, determined on a single line of action, the gifts of nature cannot be essentially improved by the moulding influence of ordinary early education. These cases are, however, the exceptions to be avoided in directing the minds of youth, and not the examples of the rule to be generally followed.

Although Judge Douglas was no scholar in the pedantic signification of the term, yet his mind was duly cultivated in the study of the law, a branch of knowledge which, when pursued merely in its details and practiced in its daily routine of office forms, may tend to obscure the perception of truth in frequent endeavors to make the worse appear the better cause, is yet in its proper study, through the expositions of Blackstone and the other systematic writers on English jurisprudence, one of the most liberalizing and enlarging pursuits to which the mind of youth or early manhood can be directed. The generalizations of this branch of knowledge were particularly fitted to improve the mind of young Douglas, and to prepare him for his future career.

But even the intellectual qualities we have mentioned are insufficient alone to account for the distinctive character of the eminence he attained. With these he might have been the dexterous pleader, the sagacious judge, the acute politician, and yet have fallen very far short of that perfect empire which he held not only over the minds of the few, but also over the hearts of the many. He had other qualities which may be cultured, but which cannot be created.

The lively sympathy with friends and associates, the intelligent and appreciating glance, the frank and hearty tone, the kindly grasp of the hand, the prompt and obviously disinterested service, these give to him to whom they belong a despotism which we are, perhaps, too proud to own, but which we cannot, if we would, resist. In the mere personal presence of Stephen A. Douglas there was a singular fascination. When you had once experienced the magic of his influence you were bound to him forever; his spirit seemed to dare you to rebel, and what was commenced by admiration for his commanding ability was consummated by his kind and genial manner. Bold, fierce, at once haughty in defiance and dexterous in fence, he necessarily

commanded admiration. But to admire is little else than to wonder; we admire a brave and gifted enemy quite as much, and, if a little terror be mingled, we may admire him even more than our true but less brilliant friend. But in the case of Douglas we loved while we admired. And this is the true key to his general popularity. His intellect conquered, but his heart secured the conquest. His innate and ineradicable kindness, and his genial manner conciliated all who fell within the influence of his power. His political and public life exhibited but the mere outward husk of the man within; it was when you looked upon the gentle amenities of his home life, upon his love and devotion to his wife, tenderness to his children, and respectful attention to his friends, that beneath that somewhat rough exterior you could discern the character it concealed.

It will not, I trust, be considered improper for me to refer to the fact that I was one among the many young men of the west who were honored by his confidence and bound to Judge Douglas by ties of enthusiastic friendship, and that therefore I speak from personal experience when I refer to the magic of his presence and the controlling influence of his character.

As I have already said, this is not the place or the occasion for entering into particulars as to his political opinions and acts, but, alike to his friends and his foes, I must say from the convictions of my head, as well as the suggestions of my heart, that history will be false to her trust if she does not record the fact that Douglas was a true patriot as well as a sagacious statesman. If he was a partisan politician, he never wore his party uniform when his country was in danger. It was a striking illustration of his character in this respect, that when the administration of our national affairs was committed to his political antagonists, he gave his hearty and generous support to the government at the moment it required his aid.

Some have lamented his death as untimely and unfortunate for his own fame, since it happened just at the moment when the politician was lost in the patriot, and when he had an opportunity to atone for past errors. But man does not change his nature so readily; Douglas was the same from the beginning to the end of his career, with views merely modified or enlarged by the expanding horizon which opened upon him from year to year, in his increasing elevation of thought and position. The words which escaped him in his last hour were the expressions of the real sentiments of his inner life.

Observant of the causes which have led to our present civil war he ever strove by adjustment to avoid their disastrous effects. "I know not," said he, "what our destiny may be, but I try to keep up with the spirit of the age, to keep in view the history of the country, to see what we have done, whither we are going, and with what velocity we are moving, in order to be prepared for those events which it is not in the power of man to thwart."

Placed at the head of the Territorial Committee of the Senate, it was under his direction that Territory after Territory and State after State were admitted into the Union. The comprehensiveness of his views was exhibited in his great speech on the Clayton and Bulwer

treaty, on the fourth of March, 1853, wherein he enforced a continental policy and refused to prescribe limits to the area over which the principles of our government might safely be extended.

His position on the Committee of Foreign Relations gave him a breadth of view in regard to our relations with other countries, which was enlarged by personal observation in foreign travel, and in special historic research. His knowledge on this subject was conscientiously applied in the way which he deemed best fitted to advance the commercial and financial interests of our whole country.

He died in the midst of the people of a district where he had been cherished and honored during the whole of his public life; in a city whose commercial and material improvement was the pride of his heart, and a type of his own character. The maturity of his growth, the fertility of his resources, and his sturdy energy, rendered his life a microcosm of the great section of our country with which he was so closely identified. We may toll the slow bell for his departed spirit, we may drape ourselves in the emblems of grief; but if his friends and admirers would truly honor his memory, they will endeavor, like him in his last days, to moderate the heat of party strife, enlarge their views of political science, and emulate his growth in moral character and clear-sighted patriotism.

GENERAL APPENDIX

TO THE

REPORT FOR 1861.

The object of this Appendix is to illustrate the operations of the Institution by the reports of lectures and extracts from correspondence, as well as to furnish information of a character suited especially to the meteorological observers and other persons interested in the promotion of knowledge.

LECTURES.

ON THE CONSTRUCTION OF BRIDGES.

BY FAIRMAN ROGERS,
PROFESSOR OF CIVIL ENGINEERING IN THE UNIVERSITY OF PENNSYLVANIA.

[Continued from Appendix to Report of 1860, p. 150]

ALL the structures for spanning openings which we have thus far considered, have been so arranged that portions of them are subjected to a tensile strain; the materials used in them are adapted to resist such a strain, and also to receive such fastenings or connexions as will enable them safely to transmit the forces applied.

The building material, however, which is most universally at our disposal, stone, although it is admirably fitted to bear a compressive force, is not adapted to resist tensile strain, and in making use of it in bridge-building we must apply it in such form and such a manner as to overcome this difficulty.

If we have two pieces of stone, neither long enough nor strong enough to span an opening in the way of an ordinary beam, we may arrange them as shown in Figure 43, preventing them from separating below by the tie rod A B.

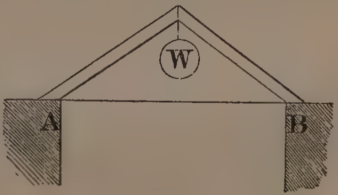

Fig. 43.

Should it be desirable that the space between the stones or timbers be left without any encumbrance, the tie rod A B may be replaced by two abutments, so firmly seated on the ground that the *thrust* of the structure will not be sufficient to push them apart or to overturn them, as in Figure 44, where the reaction of the ground takes the place of the tension rod.

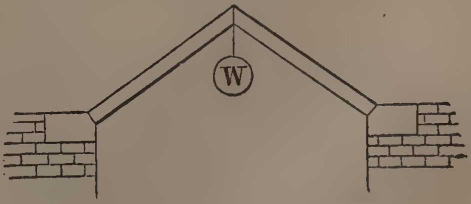

Fig. 44.

Now, if it be necessary to

sustain three loads instead of a single one, we shall have a structure such as Figure 45.

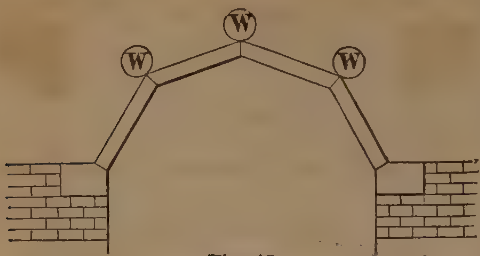

Fig. 45.

If the number of loads is very great, or, what is the same thing, if the load is distributed over the whole span, we shall have the framing in the form of a polygon of a great number of sides, or an *arch*, as in Figure 46.

Since the pieces composing such a framing or arch are small, and are only subjected to a force of compression, they may be economically made of stone or of cast iron.

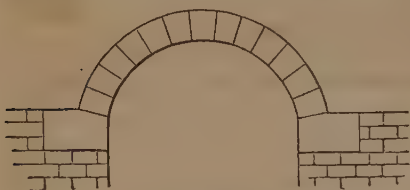
Fig. 46.

In Figure 44, by a well-known principle of mechanics, the amount of *thrust*, or tendency to separate the abutments, compared with the weight supported, (W,) may be readily determined, and it will be found to increase with the nearer approach of the

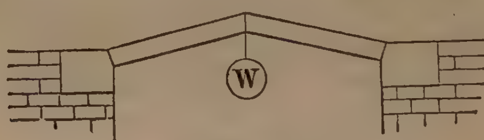

Fig. 47.

oblique pieces to the horizontal position, so that a framing, like

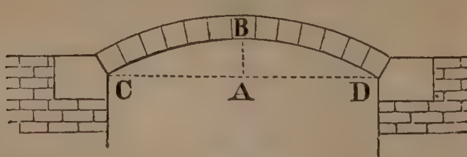

Fig. 48.

Figure 47, or an arch, like Figure 48, will exert a greater thrust than either Figure 44 or Figure 46, when loaded with the same weight. The distance, A B, is termed the rise of the arch, C D, the span, and upon their relative values the thrust of the arch will depend. In a semi-circular arch, Figure 49, no thrust is exerted at its very lowest points, A and B; it does not become sensible until we

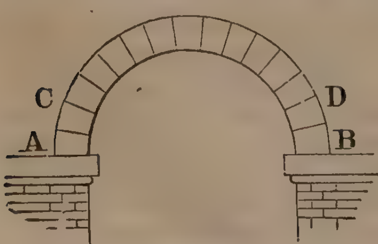

Fig. 49.

reach a point a little higher, C D, and then the arch acts as in Figure 46.

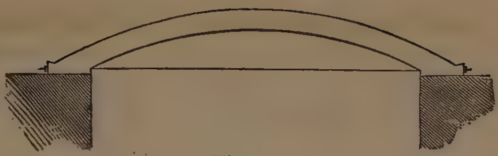
Fig. 50.

What is known as a bow-string girder, Figure 50, is only a cast-iron arch, with a tension rod, and the single iron mass may be replaced by bricks, as in Figure 51, while, still further, by taking away the tie rod and substituting the abutments, we come again to the familiar form of the arch, as in Figure 48.

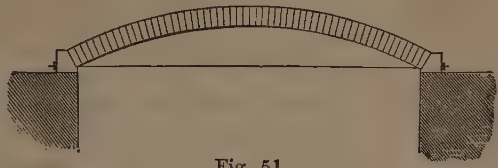
Fig. 51.

In fact, we may build an arch which has no curved surfaces of any kind, as in Figure 52, in which it is evident we have sacrified nothing of the principle by permitting the spaces above and below the dotted lines to be filled up by the projection of the arch stones.

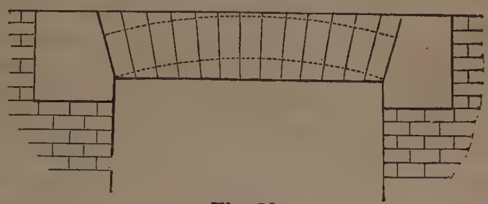
Fig. 52.

Since the weight upon an arch acts always vertically downwards, the portion at the *crown* or top, A, Figure 53, acts with all its weight in the direction of a radius, A O, of the circle, but the portions of the load towards the *haunches*, as at B C, only act with a portion of their weight in the radial direction B O; and if we desire to equalize these radial strains, we must increase the weight upon the haunches by loading them with additional material, as at D. Theoretically the upper surface of this loading should have the form shown at E, in order that the forces acting along all the radii should be equal: in practice it is usual to build up to the level of the top, as at F, by which the conditions of the problem are nearly fulfilled. Sometimes in large works the roadway over the part E is supported by small arches, the space under them being left open, thereby more nearly conforming to what is required by the theory.

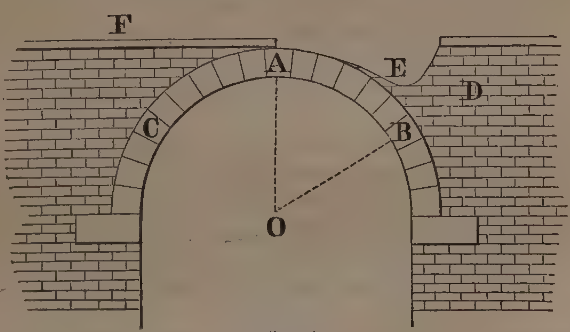

Fig. 53.

Should the arch have the simple form of Figure 46, especially if the depth of the arch stones is small compared with the span, there is danger that the weight near the crown, acting with more effect in the radial direction than that near the haunches, will rupture the arch, as in Figure 54, the crown sinking and the joint there opening on the inside, and the haunches rising. Conversely, if an arch is loaded too heavily on the haunches, as it may be by the weight of masonry at F, in Figure 53, or by soft earth in the same position, it will fail by the pushing up of the crown. Judgment is, therefore, required in planning such works, in order to avoid these accidents.

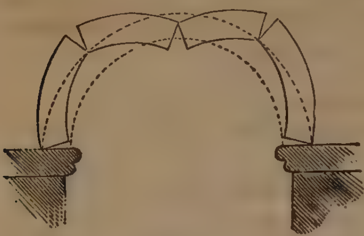

Fig 54.

The cusped arch, Figure 55, much used in certain styles of architecture, was originally designed to prevent the failure shown in Figure 54. It is evident that the inner points or *cusps* at the haunches would resist a change of form, as in Figure 54, by increasing the moment of resistance of the particles near the outside. This arch should properly be made of only four stones, as in the figure, and is therefore adapted to small structures, such as the heads of windows.

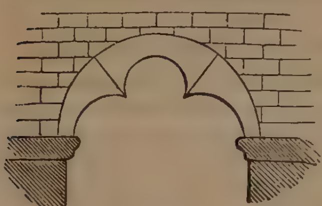

Fig. 55.

The form is a very ornamental and pleasing one apart from its utility, and admits of elaborate decoration, which is hardly the case with a simple circular arch.

We must not permit the curved form to become too intimately associated with our idea of the arch. We have seen in Figures 47, 52 that an arch need not strictly have any curved surface at all, and, on the other hand, a curved beam is not by any means an arch merely from its form. The cast-iron structure in Figure 50 ceases to be an arch when we remove the tie rod which prevents its ends from spreading, and unless we prevent such spreading by fixed abutments, a comparatively small weight will cause it to fail, by giving way to the strain of tension along its lower side, just as any other beam would do.

In a stone arch the wedge-shaped pieces or arch stones continually tend to press or pack more tightly together, and thus to keep up the stiffness of the structure.

Technically, the inner surface of an arch is called the *intrados*, the outer the *extrados*.

Frequently, as in Figure 49, the curves of these surfaces are similar and parallel; sometimes they differ, this being to a certain extent a matter of taste or of the fancy of the architect.

Curves other than circles may be employed for the *intrados*, according to certain necessities of construction. The ellipse, as in

Figure 59, is frequently employed, for reasons that we shall consider further on. Such curves are called by the French engineers basket-handles, (*anse de panier.*) For arches which bear no load except that of their own weight, the catenary curve—that which a chain assumes when fastened at both ends and allowed to hang freely—is sometimes used.

Circular arches may either be semicircular, (full centre,) as in Figure 49, or segmental, as in Figure 48.

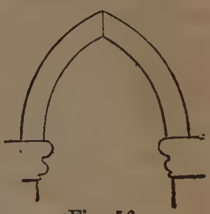

Fig. 56.

Two segments of a circle of equal radius are sometimes joined at an angle more or less acute, as in Figure 56, a form known as the Gothic arch. This form is frequently used in architecture, but rarely in bridge-building. The aqueduct of Spoletto is a rare instance of its employment in an engineering structure.

Suspension bridges, formed by stretching a rope or chain over a chasm, and supporting the foot-way from it, were very early used, since the principles involved in their construction are simple, and the materials for them are readily obtained in new countries. In parts of South America they are frequently seen across mountain chasms and streams, the material used being either flexible rods, or poles properly joined, or tough vines, such as the grape, forming a sort of rope, from two of which the foot-way is suspended or on which it is laid.

There are accounts of very ancient iron chain bridges found in India, constructed upon the same principle.

The suspension bridge may be regarded as the converse of the arch, since it is not only inverted in form, but all its parts are subjected to a tensile strain instead of one of compression. Wrought iron is the material which is naturally the best adapted to this method of construction, and is generally used.

A suspension structure, to bear a given weight, may be made with but little waste of material, since tensile strains are usually transmitted with great directness, and, being easily calculated, the minimum of material may be used. For this reason suspension works are characterized by lightness and cheapness, two great advantages.

The principal objections to them are, first, their flexibility, which can be provided against with proper care, and the space which they occupy beyond their true span—only objectionable in certain localities.

The weight of the bridge and its load tend to draw the extremities of the chains together, and if they were merely fastened to the tops of the towers which support them, these towers would be overturned. It is necessary, therefore, to extend them on the land side of the towers, and to anchor them in the ground at a considerable distance from the foot of the tower to prevent such action. In a city this is an objectionable feature, since the land chains interfere with the free passage in the streets. The fundamental principles governing the suspension bridges are so simple that it will not be necessary to dis-

cuss them more at length than we can in treating of the practical points of their construction.

There are evidently other matters to be considered in building a bridge than the mere theoretical principles involved in the action of the beam, the arch, or the suspension chain, and of these we shall now treat. In designing a bridge for a certain locality, the engineer must be governed by what are sometimes termed the *limits of location.* They may be defined as the two horizontal lines above or below which the bridge cannot go. The upper limit is fixed by the nature of the matter which is to pass over the bridge, and by the topography of the place at which it is to be built. If the structure is a foot bridge, the upper limit may be high above the surface of the stream or its banks, since pedestrians can easily mount up to almost any elevation. If it is for pack-horses or mules only, as is the case with some of the bridges of Switzerland and other mountain countries, the ascent may still be steep. For carriages the ascent must be less, and the top of the bridge must be more nearly on a level with the banks. For a railroad the upper line of the bridge must be still more nearly on a level with the surrounding country.

The other limit, or lower line, will be determined by the level of the stream, by the freshets that occur in it, and by the headway required under the bridge, if the river is a navigable one. In a locality where the stream is deeply sunk below its banks, the problem is simple; but where the country is low, and the stream apt to be swollen by freshets, the engineer must exercise considerable judgment in determining upon the best and most economical limits.

Fig. 57.

Fig. 58.

Fig. 59.

Comparing Figures 57, 58, 59, we see that the beam gives for a

given height of roadway the clearest headway under all its parts, although it is nowhere quite as high as the centre of the arch in the other figures.

In Figure 58 a small rise of the surface of the stream will much diminish the water-way just at the time when it should be the largest, a case that will not occur in Figure 57.

To avoid this the elliptical arch, Figure 59, is often used when the structure must be arched, and it presents the other advantages of increased headway and more agreeable lines to the eye.

When the engineer has determined the upper and lower limits of his intended work, (to do which he must carefully study the banks and surrounding country and collect all the information possible as to the freshets of the stream,) he must examine the ground with a view to the foundations and approaches of his bridge. Should it have but one span or bay, as in the figures, the abutments will be nearly, if not quite all, on dry land, and the difficulties to be met with in their construction will probably not be great. Should the width of the stream however be so great as to require several spans, piers must be built in the water, an operation requiring expensive and troublesome appliances.

The piers of a bridge contract the water-way and cause eddies and currents oftentimes very disturbing to the navigation, and the engineer must endeavor to use as few as possible with a due regard to the cost of the structure that he is designing. Modern practice has exhibited much fewer and thinner piers than were used by the ancient builders. With them the semicircular arch, with piers almost as wide as the openings, contracting the water-way nearly one-half, was frequently used, while now the spans are increased and consequently the number of intermediate supports diminished, while the piers themselves are made as thin as they can safely be, to support the superincumbent weight of the structure. Where the current is swift the piers should be in its direction as nearly as possible, since any obliquity to the current will give rise to violent eddies, which serve still further practically to contract the water-way, as in the case of the Rock Island bridge, on the upper Mississippi, at which the navigation, especially for rafts, is made exceedingly dangerous by such an arrangement of the piers.

Many experiments have been made upon the proper form to be given to piers in order that they may obstruct the passage of the water as little as possible, resulting in the fact that the same form which enables a vessel to move easily through the water, permits the water to flow past a fixed pier with the least commotion.

When the number and size of the piers are decided upon, the bottom of the river must be examined with a view to their foundations. Many ways of providing a firm base on which to rest the masonry have been adopted, the simplest being to remove by a dredge the soft mud which generally lies on the bottom and then to drop rough stone on the proper point until the pile appears above the surface, when the masons can commence their work. This method suffices where labor is dear and stone plenty, and where the contraction of

the water-way by such masses is not of importance. Another plan is to make strong timber cribs and to sink them, filled with stone, to the bottom, permitting them to reach just to the surface of the water, a method largely adopted in this country with good results.

The neatest, though much most expensive way, is to build a water-tight wall or *coffer-dam* around the place of the pier, and after pumping out the water so as to lay bare the bed of the stream, to build up the foundations to the surface with concrete or with regular masonry. The coffer-dam is usually made by driving two rows of piles, one outside of the other, around the space to be laid dry, and then by packing clay in between them so as to render the enclosure impervious to water. Pure clay is not as good for the packing as that which has a slight admixture of fine gravel or sand. When the stream is deep it will be very difficult to prevent the water from soaking through the clay puddling, and a steam pump is often required to keep the space free from leaks and breaks which greatly delay the work and add to its cost; but it is quite practicable, with proper precautions, to lay foundations in this way in very deep and rapid rivers.

We have so far supposed that the natural bottom is suited to bear the weight of the structure, but frequently we find soil of such a nature as not to be able to do so, especially if the pier is thin, and therefore presents only a small bottom surface; in such cases it will be necessary to provide some means of solidifying the bottom, or of distributing the weight over a surface sufficiently large to prevent its sinking. Where the bottom is nearly firm enough, a platform of wood, somewhat larger than the pier, carefully laid, will be sufficient to prevent any sinking. Such a platform will last under water for centuries, many having been found in a good state of preservation under old Roman bridges.

In place of a wooden platform a bed of concrete or beton may be employed, composed of a mixture of mortar made, if necessary, of hydraulic lime and gravel or broken stones, with some sharp sand, which is thrown into the space excavated to receive it, rammed and levelled, and allowed to harden into a solid mass, upon which the masonry is built. Concrete should not, as a general thing, be exposed directly to the action of running water, since it may be rapidly worn away, but with the proper precautions it forms the best of foundations.

Should the soil of a particular locality not prove sufficiently strong for this, however, recourse must be had to *piling;* that is, to driving posts or piles of timber to such a depth that they will not settle any further, and laying a platform upon their heads on which the masonry will rest. The piles, with the bark stripped off, the points sharpened or shod with iron, and the heads defended by iron rings, which are afterwards removed, are driven by a heavy weight falling upon them until they will go no further, or rather only a fraction of an inch with several strokes. They are placed in rows, at distances apart depending upon the nature of the ground, and then their tops being sawed

off to a level, heavy timbers are bolted to them to receive the platform.

Whenever there is any doubt of the foundations, piling will be found to insure the greatest safety and permanence, although it is frequently costly; it is only interfered with by natural springs in the ground which loosen the material around the piles and cause them to settle or to rise. Piles may also be used to advantage to prevent the spreading out of a loose, yielding material, such as quicksand. For this purpose piles sawed out square, so that they will fit tightly together, are driven around the material to be enclosed, touching each other, and connected at the top by string-pieces; the soft material thus confined will present a good bearing mass, after being covered with a wooden platform.

Solid rock is generally the most certain and satisfactory foundation, but the labor of preparing its surface under water to receive the first courses is considerable; hard, gravelly clay and cemented sands are nearly as good; sand, which makes the best of foundations on the land, must be narrowly watched under water, since it is easily moved by currents by the obstruction in the channel, which may wash it away and undermine the structure.

The abutments or land supports of the bridge may, of course, be founded in the same manner as the piers; but being mainly on dry land the difficulties attending them will usually be less.

Piers have been sometimes founded in a stream by building them on the bottoms of flat scows or caissons and permitting them gradually to sink, as the weight of masonry is increased, until the whole mass rested upon the bottom, which has been dredged level to receive it; the sides being detached, the bottom is left under the pier as a platform.

Cast-iron piles, terminating in an auger-shaped flange, which enables them to be screwed into the soil, invented by an Englishman named Mitchell, have been extensively used with good results, especially in the foundation of light-houses and beacons along the coral reefs of the Florida coast. They are easily screwed down in places where ordinary piles are difficult to manage, and their resistance to a vertical pressure is enormous, owing to the surface exposed by the wings of the screw.

Within a few years since the general introduction of iron into engineering practice, a system of foundations by means of cast or wrought-iron cylinders sunk into the bottom of the river has come into favor. These cylinders or pneumatic piles, as they are called, were first proposed and used by M. Triger, an engineer of the north of France, for sinking a shaft through a quicksand; and are known in England as Pott's pneumatic pile, although he is really not the inventor. The cylinders, from six to ten feet in diameter, prepared in the proper lengths, are bolted together and sunk vertically until the lower edge rests on the earth; the top is then closed by a plate, to which is fitted an air-lock or chamber furnished with double doors, like the vestibule of a house, so that a person can enter the lock and

shut one door behind him before opening the other, which leads into the interior of the cylinder.

All being made tight, air is pumped into the cylinder by an engine, and the water forced downwards in the pile until it is all driven out at the bottom; workmen then enter through the air-lock, which only permits a small portion of the enclosed compressed air to escape as the doors are opened, and descending to the bottom excavate the soil under the edge of the pile and in the centre allowing it to sink down gradually by its own weight. It is directed in a vertical position by guides above. As the pile sinks, new cylinders are added to the top, when necessary, and after the whole is down to a firm foundation the interior is filled up with rough stone or concrete, the air-lock removed, a permanent cap substituted, and the superstructure raised upon it.

In loose, sandy bottoms these piles have been sunk by permitting the air to rush out under the edge of the pile and by carrying out with it the sand so as to make an annular channel into which the pile settles by its own weight.

Many bridges in England and on the continent, and some in this country, have been built in this way with great success. One of the most interesting examples is that of the new bridge over the Rhine at Kehl, near Strasburg, where caisson piles were sunk to a depth of sixty feet below the surface of the water.

Frequently the bed of the river, between masonry piers and for a short distance above and below them, is paved, planked, or covered with loose stone, to prevent the current from undermining the structure.

The foundations having been completed, and the piers having been built up to a certain level, the bottom of the beam of a truss bridge and the spring of the arch of a stone bridge, preparations must be made for adding the superstructure.

The truss or beam may be either made on the shore and floated and raised bodily into its position, as in the case of the water tubes of the Britannia bridge, or it may be built in its place upon a scaffolding or false work erected to support it, as in the case of the land tubes of the same bridge and of most of the truss bridges built in this country.

For a stone or cast-iron arch a frame called a centring must be employed, as shown in Figure 60, the top of which has the form of the

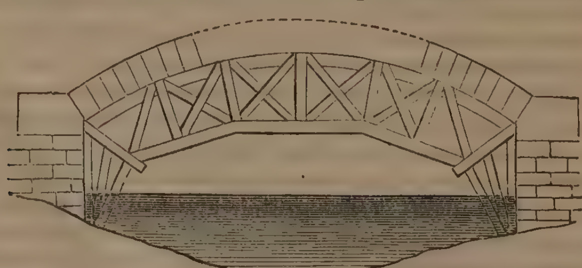

Fig. 60.

inner side of the arch, so that when the stones are laid upon it they

come into their proper places in the curve. If the stream can be occupied during the construction of the bridge by piles driven across it, the form of the centring will be simple enough, for it can be supported along its whole length from below ; but if the water-way, as is frequently the case, must be left clear all the time, considerable ingenuity is sometimes required in designing a structure which, only supported at its ends, shall sustain the varying loads during the progress of the work without change of form.

After the centring is up, the construction of the arch is commenced by laying the first stones near the abutments on both sides, and gradually building up towards the centre ; and as the weight is in this way increased from the ends of the frame towards its middle, the centring must be so trussed as to resist the change of figure which this operation has a tendency to produce.

After the arch-stones, which are cut previously of the proper size and shape, depending upon the curve of the intrados, are all properly laid up to the middle, the last stone, usually called the keystone, is fitted tightly into its place at the crown of the arch, and after permitting the structure to rest for a short time, the centering is slightly lowered to permit the stones to commence to bear tightly upon each other. To enable the centre to be thus lowered, or *struck*, as it is termed, it is made at first to rest on wedges on the lower part of the frame, and these wedges being slowly driven back the centre gradually sinks.

In the bridges of the Alma, the Invalids, and of St. Michael's, all in Paris, an arrangement, invented by M. Beaudemoulin, was substituted for the wedges with success. Upon the fixed portion of the frame a series of sheet-iron cylinders filled with fine dry sand, rested, into which fitted wooden plungers which rested on the sand, and upon these plungers rested the centring. When the centre was to be struck, a small hole left at the bottom of the cylinder was opened, and the sand running slowly out permitted the upper works to settle down gradually.

When the engineer considers the mortar sufficiently set, the centre is lowered still further and taken away, leaving the arch to support itself ; the rest of the masonry work is then carried up, the spandrels filled in to the level with the crown of the arch, and the pavement, sidewalks, and parapet walls added.

Great care must be taken that the rain-water which falls upon the surface of the bridge is not allowed to percolate through the structure ; as it not only carries portions of the lime with it and disfigures the surface and the under side of the arches, but is frozen in winter, and thus tends rapidly to destroy the bridge. Gutters must be laid on the top, and the water from them conducted away in pipes through the piers, while the use of asphalte or bitumen as a water-tight covering to the backs of the arches, is highly to be recommended.

As a general rule, it seems well to avoid much architectural ornament on a stone bridge, unless it has some obvious connexion with the constructive features. Many of the European bridges are in-

jured in appearance by pediments, cornices, columns, and pilasters, which are entirely out of place.

There are enough projections and other features which occur naturally in the construction to give the necessary relief, and structures depending upon these alone have always a neater, bolder character than those which are encumbered and enfeebled by useless ornaments.

In the United States but few, if any, very large stone bridges have been built, and we must look to Europe for examples. The ancient aqueducts, the characteristics of which are usually very high, thin piers and small arches, are among the most beautiful of the remains of Roman enterprise and magnificence, while the river bridges of the same people, however good of their class, are surpassed by those constructed in the sixteenth century and later, when larger spans, lighter piers, and segmental and elliptical arches were introduced by Ammanati, Perronet, and others.

The ellipse or more properly the curve of several centres, Figure 59, presents several advantages over the circular curves. Apart from the increased water-way, its form is much more pleasing to the eye, not only in its own variety, but because in it the broken line which occurs where a segmental arch joins the face of the pier or the abutment is avoided, and because the flatness of the arch near the top gives an appearance of lightness which cannot be got in any other way. The bridge of the Trinità over the River Arno, Florence, Italy, built by Ammanati, in 1566, is the most graceful structure of its kind that has yet been produced, and it owes its beauty principally to the use of this curve. The piers of this bridge are, however, thicker than they should be, since practice has reduced these parts very much in later structures, with advantage both as to appearance and to the water-way left beneath them.

At the present time, when many large bridges are built in isolated places for railway purposes, cheapness and quickness of construction are matters of the first importance, and as these necessities have led to the general use of wood and iron, we shall finish this subject by a description and comparison of two of the most important works of late date. When the Chester and Holyhead railroad was to be carried across the Menai straits, which separate the island of Anglesea from the main land of Wales, a suspension bridge something like a famous carriage bridge built by Telford at the same point, was proposed, but the opinion of the distinguished engineer, Robert Stephenson, supported by nearly the whole of the English profession, was, that it was impossible so to overcome the flexibility of a suspension bridge as to fit it for railway traffic, and the idea was accordingly abandoned. Several plans were then proposed—among them that of a cast-iron arch—but owing to the restrictions placed on the work by the admiralty, some arrangement was required which would avoid interference for any length of time with the free passage of vessels through the strait, and nothing like centring could be used.

Mr. Stephenson first determined to have a wrought-iron truss with strong top and bottom, and thin plate sides or web supported by chains at the central point; the chains, however, were afterwards

abandoned and the simple beam decided upon. The bridge is composed of four spans, the two centre ones being 460 feet and those at the ends 230 feet. The land beams, or tubes as they are called, were built in their places on scaffolds raised from the ground; but the tubes occupying the centre spans were built on platforms on the shore, afterwards floated into position, and raised by hydraulic presses to their places, one hundred and four feet above the level of the water.

It is difficult, without a detailed description, to give an idea of the magnitude and interest of this operation; but when we know that each beam weighed 1,589 tons, was 470 feet in length, and had to be floated during a single tide, from its original place on the shore, several hundred yards to the foot of the piers, brought nicely into a niche in the masonry while still on the floating pontoons which supported it, and then hoisted steadily through a vertical height of 104 feet, we can readily imagine that the work required the greatest care and the most perfect arrangements. There being two large spans to the bridge and two beams to each span, for the double track, there were four to be thus moved, and the successive operations were watched with great interest by the large crowds that assembled to witness them.

These operations, as well as the magnitude of the work, gave this bridge a place in the public mind, and a world-wide importance that perhaps it hardly merits in an engineering point of view.

The two large spans are 460 feet in the clear—the small ones 230. The total length of the bridge is 1,511 feet, and the single line weighs 3.1 tons per lineal foot. "The two tubes, in their entire length and their complete state, contain 9,360 tons of wrought iron, 1,015 tons of cast iron, and 165 tons of permanent way. They are composed of about 186,000 separate pieces of iron, pierced by seven millions of holes, and united by upwards of two millions of rivets. They contain 435,700 feet or eighty-three miles of angle-iron, and their total weight is 10,540 tons." The total cost of the bridge was about three millions of dollars.

Elaborate preliminary experiments, costing over twenty-five thousand dollars, were made to determine the proportions of the beams, by Mr. Fairbairn, to whom much of the credit is due.

The history of this bridge and its construction, in two beautiful volumes, with elaborate plates, by Edwin Clark, will always be considered a classical work both by the practical engineer and the student of science.

The other structure to which I referred is the celebrated bridge built over the Niagara river for the railroad passing through New York and Canada, by John A. Roebling, C. E. The difficulties here to be overcome were the crossing of a chasm 800 feet wide and 245 feet deep, at the bottom of which was a deep river with a furious current, in which no boat could live or no scaffolding could be fixed; of course no central piers could be used, and a single clear span was required.

A carriage-bridge had been constructed at this point, which is

about a mile and a half below the falls, by Charles Ellet,* in 1848, and in 1852, it having been decided to carry the railroad across the river, the large bridge was commenced at the same locality, by Mr. Roebling. The fact that the English engineers had decided that suspension bridges were impracticable for railroad purposes, made the proposition to construct one at this place a bold enterprise, and great praise is due not only to the genius and skill of the engineer, but also to the president and directors of the road to whose liberal views the engineering profession is indebted for this grand experiment.

Suspension bridges for ordinary traffic were in common use in Europe and in this country, and the well-known one at Fribourg, with a span of 807 feet and an elevation of 167 feet above the water, built in 1830, had remained in good condition after more than twenty years of use; but the doubt existed whether such a structure could be made stiff enough to resist the undulations caused by a moving weight as heavy as that of a locomotive and a loaded train of cars.

The cables of the Niagara bridge are four in number, each ten inches in diameter, and made up of 3,640 iron wires of No. 9 gauge, anchored firmly into the solid rock about 230 feet from the edge of the cliff, and passing over massive stone towers 76 feet in height, and from these the roadway is suspended by wire ropes. Iron drawn into the form of wire is known to have its strength greatly increased in proportion to its weight, and, therefore, it can be much more economically employed than in the form of rods or chains.

Were the roadway merely made strong enough to support the load to be brought upon it, the bridge would be depressed, owing to the flexibility of the cables at the point occupied by the load, and would rise at other points, inducing an oscillation that would soon be destructive to the bridge, and the roadway is therefore trussed or framed after the manner of a timber bridge, so as to resist any local depression and to distribute the weight over a great length of the cable, and thus prevent such oscillation.

In addition to that, a number of wire stays run from the top of the tower to points in the truss, on the principle shown in figure 19, which fix those points and thus add materially to the stiffness. Again, the track itself rests upon longitudinal girders of great strength, which serve to distribute the immediate load to more distant parts of the truss. These are briefly the points upon which the stiffness of the bridge depends. The railroad is placed on the upper floor of the truss, while the lower is used for carriages and foot passengers.

It was held by English engineers that a truss which would give sufficient stiffness to the cables would be strong enough to sustain itself and the load, or that the cables would be useless, but this is plainly disproved both by calculation and by the practical result of the Niagara bridge, in which the truss is exceedingly light, and when it serves only the legitimate purpose of stiffening, while the weight

* While these pages are going through the press our country is called upon to mourn the untimely death of this eminent engineer, who, with generous patriotism, devoted his talents and his life to the defence of the Union.

is borne by the cables themselves. The bridge has now been in constant use, and since the eighth of March, 1855, when the first engine passed over it, with perfect success.

It is the duty of the engineer to construct his works so that, while durability is insured, the object shall be attained at the least cost. It has been frequently said that there is no limit to engineering achievements but the want of money, and much less credit is due to him who accomplishes an important result with a large expenditure than to him who does the same with limited means. This is especially true of the public works of this country, where the lines of communication are very long and frequently pass through sparsely settled regions, which could not by their local traffic support expensive structures. It will be interesting, therefore, to compare the cost and weight of the two structures which we have described with the view of determining their relative merits on these grounds.

The Britannia bridge is 1,511 feet in length, the Niagara 800. The weight of one line of the first is 4,680 tons or 2,340 tons for 755 feet against 1,000 tons for the 800 feet of the second, or nearly twice as much. Again, the Britannia bridge, completed, cost three millions of dollars for a double track, while the Niagara bridge cost four hundred thousand for a single track—rather more than half the length; and taking into consideration that the piers, foundations, &c., would cost almost as much for a single line as for two, the ratio of cost would be about one to two and a half, a vast difference in favor of the suspension bridge.

The proof of the practicability of cheap bridges of great spans, due to Mr. Roebling's talents, forms a new era in the art of engineering. Communications which were hitherto considered impossible may now be made; regions like those of the west coast of the United States, intersected by deep ravines with vertical sides, may be traversed by railroads, and rivers may now be spanned by bridges at places which were before entirely impassable.

Mr. Peter W. Barlow, C. E., of England, after a careful personal examination of the Niagara bridge, has not hesitated to propose a plan for spanning the river Mersey, at Liverpool, by a suspension bridge three thousand feet long, at a height of one hundred and fifty feet above the water, with towers four hundred and fifty feet high, at a cost of five millions of dollars.

The greatest engineer is not, however, he who builds the largest work at a greatest cost, but he who, by the introduction of new principles, or by the ingenious application of those already understood, extends the practice so as to enable us to surmount new difficulties with economy and safety.

LECTURE

ON

THE RELATIONS OF TIME AND SPACE.

By PROFESSOR S. ALEXANDER,
OF THE COLLEGE OF NEW JERSEY.

MANY of the truths with which we are conversant have not so much to do with things as with the relation of things. There are no such things, in themselves considered, as 3, 4, 7, or $2\frac{1}{2}$; and even length, breadth, thickness, and capacity are not things in themselves considered, although they belong to all material substances. As with us, so far as we have to do with them, time and space are not things, but the relation of beings and things. We occupy space, and pass our lives in time. There was, therefore, force as well as truth in the observation of Franklin: "Dost thou love life, then do not squander time, for time is the stuff that life is made of." We avail ourselves of this pithy saying of his Poor Richard in order that we may vindicate the necessity for our going a little further and ascertaining the material of which time itself is constituted. This, in the largest sense of the term, is duration. Now, without attempting to define either space or duration, we may readily describe both. Thus it will be conceded that space is that wherein there is room for the whole material creation, so that bodies in it may exist apart. And so, in a somewhat metaphorical sense, duration is that wherein there is room for events to occur; it is that wherein, in one sense, things may happen, or in which it is essential to space that its portions should be diverse in position. All experiénce tells us that our right hand cannot occupy the same place with our left, and the accurate experiments of natural philosophy abundantly confirm this conclusion. Not only so, but also when my right hand goes to the place where my left hand was, it forsakes its place, leaves behind that part of space it occupied, and goes to another part of space, so that it is essential to space that the portions of it should be diverse in position. It is just as essential to duration, in so far as we have to do with it, that its portions should exist in succession. Tuesday cannot, by any device, become Wednesday; it has preceded that day. Thursday cannot, in like manner, become Wednesday; it must succeed it. It is essential to space, therefore, that its portions should be diverse, and essential to duration that its portions should exist in succession. It is, moreover, a result of all

experience that within the same portion of duration, as far as can be discerned, there is room for the same or similar events to occur in the same way. It is the result also of all experience, so far as we can trace the matter, that one portion of duration is like another, so that no portion of it goes on faster than any other. Now, it is the uniform continuous flow of duration, thus parcelled out, that constitutes absolute time. Relative time is a portion of duration whose limits are marked by events. You have something to mark when that duration begins and when it ends. Absolute time will flow on whether you mark it or not. When that portion of time is marked by events, so that you know where certain periods of time begin and end, it becomes relative time. As then we must speak of the limit when a portion begins, not when it ends, it is desirable that we should distinctly indicate what we mean by limit, whether of space or duration.

Now with regard to the limit of anything that occupies space. The outside of this table before me is no part of the table; it is only precisely where the table ends that outer space begins. The outside is not *somewhat* in the same sense with the table itself, but only *somewhere*—where the table ends, and the outer space begins. But this is still *somewhat* in its own sense. It has breadth, it has length and superficial extent, such as may be measured by a square foot. But the outer edge is not somewhat even in the sense that it covers something; it merely penetrates space, instead of dividing it. The very end of the outer edge is not somewhat even in the sense of a line, for although the outer edge was long, penetrating space, the very end of it is only *somewhere.* Thus it is with the centre of a sphere. It is not somewhat. When we depart from it at all we forsake the central position we occupied. But you may ask is it not somewhere? Oh, yes; precisely at the middle; at the same distance from the surface on all sides. So also with the midnight, with which Tuesday shall end and Wednesday begin. It is not somewhat in duration. It does not last at all. When midnight arrives, that instant the following day will be here. It is not *somewhat* in duration, but only *somewhere;* it is at the precise time when one day ends and another begins that, if I may be permitted to coin a word for the occasion, it is *somewhen.* It lasts not at all, and therefore is only a point of time, that is an instant. There is a distinction between an instant and a moment, for a moment is a real portion of duration—a small but indefinite portion—while an instant is no portion of duration whatever.

The natural measure of time, Lord Kames tells us, is the succession of our thoughts. When the varied incidents of a pleasant journey pass before the mind in review, the interval thus spent appears to have been a long one. But if during a tedious journey, or a fit of the toothache, or, to come still nearer home, a dull lecture, we find time to be long, it will certainly not be long in review. So, then, time may appear long or short, according to circumstances, and it is perfectly evident that this rule of Lord Kames cannot answer as a good measure of time. It has been also supposed that the insects which

live but for a day—the ephemera—may have so many sensations (we cannot call them ideas) during the course of that day that this period may appear on the whole as a long life. Such a measurement of time, varying according to circumstances, is inappropriate; it is evident, therefore, that some other must be sought.

In a good standard of measure of time there are two or three properties which are indispensable. And first, it should be readily accessible: a measure shut up so that it could not be reached would be good for nothing. Second, it should be convenient, both as to size and mode of application. Third, the measure should, if possible, be invariable. Now, there is a standard in nature which embraces these three properties, and that is, the rotation of the earth about its axis.

It is for some purposes convenient, as regards size and mode of application, inasmuch as it is nearly the length of the ordinary day. It possesses the third property, invariability. But how do we know that the rotation of the earth is invariable? This fact may be ascertained by comparing it in the long run, or with something else known to be invariable. To illustrate this, suppose the minute hand of a clock by some means to go too fast; when it arrives at 12 the hour hand will be some way behind the position which it would otherwise have occupied; and this discrepancy, however small at first, if permitted to go on, will become more and more evident. The moon revolves about the earth in a certain mumber of days, as days now are. Now, if counting ages backward, the day had been changed, the whole number of days, according to our present measurement, would not correspond to the exact number occupied in the moon's revolution, and therefore the position of the moon on a given day, by this backward reckoning, would be found to be untrue. That this is not so is found by a comparison of computation with the observation of an eclipse of the moon more than seven centuries before the Christian era, and from it is safely concluded that the rate of the earth's rotation has not changed one three-hundredth part of a second. There are causes which might change this. The most prominent among these is a change of bulk arising from a loss of heat. The loss of heat does not, in every case, produce a shrinking. Cast iron presents a familiar example, as it at first expands in cooling. It may, therefore, happen that within the earth a great deal of expansion and contraction occurs, though there is no sensible shrinking on the whole. Even if the earth actually shrunk, the loss of heat and size would not diminish the force of rotation at all, but the time of rotation will diminish with the circuit. If I take a ball with a string attached, and, by means of the string, cause it to revolve around my arm, and then wind up the string, as it proceeds in its revolutions the motion of the ball will become quicker and quicker, until the string is entirely wound up.

Let me here observe that the earth has more than one motion. It revolves around its axis, and in that revolution pauses not, while it also moves around the sun. Before proceeding to consider this fact, it is desirable to ascertain when a sphere which has two motions has completed a rotation.

For this purpose, suppose two spheres to be situated as in Figure 1, the one at A, the other at B, having a meridian on the one parallel to a meridian on the other, and that the angular velocity of rotation is the same in both. The audience will perceive that the meridian will continue parallel, and be so found at the end of the rotation. If, instead of this, we suppose that the sphere A, while it revolved, was also transferred to the place of B, then the meridian on A, when it arrives at B, would be found at the completion of its rotation to be parallel to its first position. Noon at any place occurs when the plane of that meridian passes through the sun in the direction of C. If, after one rotation, the earth were transferred to B, then the meridian already shown in the figure must be in a direction parallel to its former position. But noon will not have occurred. To accomplish this the earth must have revolved as much more as the direction of noon has meanwhile changed; that is, until the meridian reaches the line in the figure passing from B to the sun. Now, if the earth's due eastern motion in its orbit were equable, the solar days would be equal, for the excess above a whole rotation (already described) would in every case be the same. This cannot be the case, especially because of two reasons: The first is found in the oblique position of the orbit itself. The earth does not move due east, but eastward, insomuch that if the direction of the circle passing through A, in Figure 2, represent a due eastern direction, the circle through B would represent that in which the earth is actually moving. It will be perceived on either supposition that a quarter revolution eastward would be accomplished in the same time, or the position as regards a due eastern motion would be the same at four points, these being the equinoctial and solstitial points. This is artificially registered on Figure 5, in which the first curve A is made to intersect the horizontal line at the times of the equinoxes and solstices.

Fig. 1.

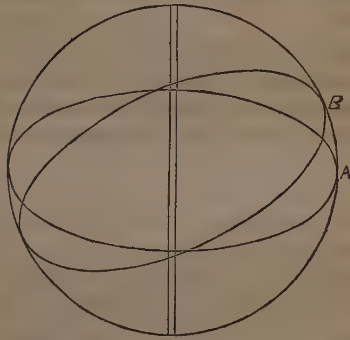

Fig. 2.

Fig. 3.

Now, in passing from the equinox to the solstice, the due eastern motion, as in Figure 3, E B, is less

than that of E A, the actual motion in the orbit. With reference to its average motion in a due eastern direction, it may be said to lag behind in its reckoning. The excess of the solar above the sidereal day will, therefore, be less than usual. Our time by the sun must gain, and a full quarter of the revolution will still be completed, as before shown, at the solstice. The fact that time by the sun must gain during this interval is indicated artificially in Figure 5 by the portion of the curve A which corresponds to that interval being placed above the line. In passing from the solstice to the equinox the opposite effect will take place; our time by the sun will lose, and this is indicated artificially in Figure 5 by the portion of the curve A which corresponds to that interval being placed below the horizontal line. The other cause of irregularity is found in the orbit itself. This is elliptical. The deviation from the circle is exaggerated in the representation of Figure 4.

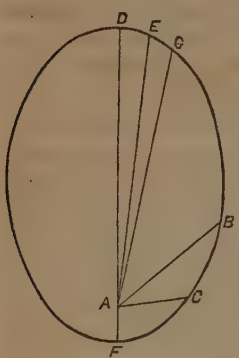

Fig. 4.

The case of motion in the curve requires that the space, such as C A B, passed over in a given time by a line drawn from the sun at A should be equivalent to the space, D A E, passed over in the same time when the earth is passing through any other portion of its orbit. It will be seen that it will require the angular velocity of revolution about the sun to be greater when the earth is nearer to him. Each half of the elliptic, F B D, will be described in the same time. In passing around from F to D, that is, from January to July, the due eastern motion of the earth will, for the reasons now stated, be greater than the average. This will cause the excess of the solar

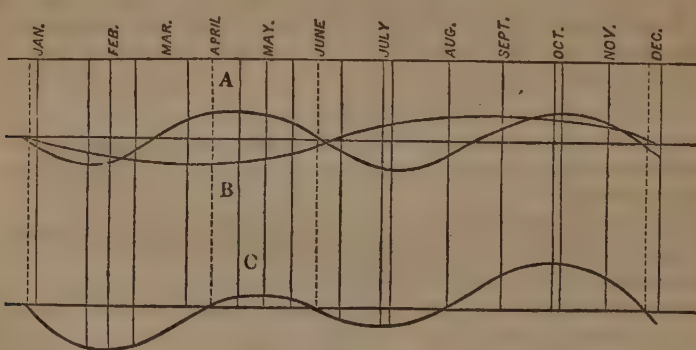

Fig. 5.

above the sidereal day to be greater than usual, and our time by the sun will lose. This is represented artificially in Figure 5 by the portion of the curve B which corresponds to that interval being placed below the horizontal line.

During the other half of the year the opposite effect will take place. This is indicated by the other portion of the same curve

being placed above the horizontal line. The mean solar day is the average of all the solar days in the year, and the deviation from it, arising from both the causes already specified, being proportionably represented at any date in the year on the two curves, A and B, already described, the effect arising from the combination of the two will be represented by curve C, which indicates the equation or correction of time. This will be found to be nothing at irregular intervals, to wit: about the 15th of April, 15th June, 1st September, and 24th December.

It may be well to notice to some extent the difference of local time, as it will enable us readily to answer a curious question that has often been discussed at much length: If from a first meridian, at which it is noon—say of Tuesday—we count around eastward, we shall find it to be later and later in the afternoon of Tuesday, until arriving at the opposite side of the earth, in longitude 180, we shall find it to be the midnight with which Tuesday is about to end and Wednesday begin; but if from the same first meridian we should count around westward, we would find it to be earlier in the morning of Tuesday, until arriving again at the longitude of 180 degrees, we should find the time to be the midnight with which Tuesday is about to begin. By comparing these two results it will be perceived that the difference of time between two places situated beyond 180 degrees—one on the one side and the other on the other—must be all of 24 hours. This difference, which exists about midnight, must continue to exist as time moves on, at any other hour of the day. In passing this limit, therefore, the name of the day of the week must be changed in the reckoning. Now, as Christianity, and with it civilization, are overspreading the earth, it would seem most suitable that the first meridian of reference should be the meridian of Jerusalem.

The question to which allusion has already been made, is as follows: Suppose a traveller to be transferred westward as fast as the earth revolves from sun to sun eastward, so that if at the outset it were noon with him it would continue so, it is required to know when and where it would be necessary for him to change the name of the day. Now, it has already been seen that the place *where* this ought to happen, is in the longitude 180 degrees from the first meridian fixed upon, and the time when this must occur is noon by the very conditions of the problem.

I will now notice the calendar, though I may do it but briefly. It has, of course, for its object the distribution of time, a primary division of which is the day. Anciently the twenty-four hours of the day were named after the sun, the moon, and the five planets, as follows: Sun, Venus, Mercury, Moon, Saturn, Jupiter, and Mars. The first hour of the first day was named after the sun. This also gave name to the day, and it was called Sunday. The other hours of the day were named after the other planets, &c., in the series; and then the series was begun anew, and having been gone through in this way three successive times. twenty-one hours received their names, and the remaining three hours were named by commencing the series a fourth time and proceeding as before. The first hour of

the next day received the name of the fourth in the series, to wit, the moon; and this also gave name to the day, so that it was called Moonday or Monday. Thus the several days of the week were named. The French names of the days of the week still bear marks of this process. In the English names of the days the names of the old Saxon deities are introduced in place of those of the gods of ancient heathenism. Thus we have Sun's-day, Moon's-day Tuisco's-day, Woden's-day, Thor's-day, Friga's-day, and Seterne's-day.

With regard to the months, January is named from Janus; February from Februa; March from Mars; April from the Latin Aprilis, called from aperio, to open, being a spring month of the year; May from Maius; June from Juno; July from Julius Cæsar; August from Augustus Cæsar, and the remaining months from their order in the Roman calendar, September being the 7th, October the 8th, November the 9th, and December the 10th. Our present irregular arrangement is said to have arisen in part from the pride of Augustus Cæsar, who insisted on having as many days in the month named after him as that named after Julius; in consequence of this but twenty-eight days were left for February.

In the next place we come to epochs; an epoch is the period from which any number of years is reckoned. The birth of the Savior is an epoch, and the years reckoned from it constitute a Christian era. According to the Christian era, then, we have arrived at the year 1860. The question whether 1850 ends the first half of the century, or whether it begins the second, is not a question for speculation. It is a mere question as to what is the fact. It is somewhat analogous to the question whether a railroad company had directed the first milestone to be placed at the beginning or end of the first mile, and so onward. At the outset it might be a speculative question as to which position would be the better; but after the arrangement had been made the question would be merely what had been done. Now it is a fact that those who had the arrangement of our chronology so settled the matter that the year one should indicate the first year of Christ; so that the year one did not end until the first year was completed. Hence, the first 100 years did not come to an end until the year 100 was completed. The first 1800 years did not come to an end until the year 1800 was completed; and 1850 years of the Christian era will not have come to an end until the year 1850 shall have been completed. The succession of 100 years constitutes a century, the longest period yet employed in the measure of time, because (observes La Place) "the interval that separates us from the most ancient of known events has as yet required no other." Duration, however, is inexhaustible, and we next proceed to consider the infinites both of space and duration.

Now, whether we regard space forward, backward, sidewise, upward, downward, or obliquely—it matters not in what direction—it is absolutely without limit. Not merely is the limit so remote that you cannot ascertain it, but space is really boundless in all directions, absolutely infinite; so, too, antecedent to all things we still behold, self-sustained upon the throne of His adorable perfections, the great First Cause, He who, being the origin of the first beginning, Himself

has none, but ever was, as now, *from* everlasting. It is in this perpetual precedent, this underived antecedent of the divine pre-existence, that we find the realization of eternity past; so, too, far beyond the ages to come—innumerable though they may be made by the flight of years, immeasurable though they may be by the flight of centuries—must still continue the ceaseless, unalterable being of Him who alone hath immortality underived, and in that is eternity future.

Now it is the combination of both of these, nothing less than this, nothing short of it, that constitutes for us the absolute infinite of duration; that is, from everlasting to everlasting. Dividing the two eternities, as it were, the one from the other, in all worlds at once stands the instantaneous present. Thus it was from the first moment of the existence of the first created being, or thing, and thus it will be when the present system of things, like a worn-out garment, is, as it were, folded up and laid aside. Through the ever-present now, the eternity future flows by, and in the metaphorical sense is transferred, moment by moment, to the eternity past. We recognize this fact even in our ordinary language; thus we say when to-morrow comes [to us] and not when we come to to-morrow.

We are now somewhat prepared to discuss the question whether, if all the material creation were annihilated, what might be called space would remain? On the one hand it would seem that it would not be so, because the outside of this block, for instance, is not somewhat, but only somewhere, and disappears when the block is removed. Hence, we might conclude that what is still more complete outside would disappear if all else were gone. On the other hand, the outside of this block has a dependent existence. It goes with the block, though it cannot exist by itself. Wherever the block goes the outside goes with it. But the block occupies a portion of space and leaves it behind when it is removed to another. Hence, if all else were gone it would seem as if space must still exist. Now the statement that if all the visible creation were removed, there would still be room for another, proves nothing. It but argues that if there were another creation it would exist as now in space. But it does not show what would happen if all these things were gone, or in the absence of everything tangible. This is a matter so far beyond the pale of our experience we can assert nothing with respect to it. We care not, however, whether this question be decided in the one way or the other; but we most uncompromisingly assert that space cannot exist independent of the great First Cause, from whom not merely all things were created, but by whom they also *consist*; who has not merely made these things *what* they are, but *as* they are. On Him are dependent not only all things but all relations of things.

Could space, indeed, exist by itself? It would be a thing by itself and not a relation of things; then must it also be independent, and if it were independent it would be self-existent; if self-existent it would be interwoven with the existence of the Almighty. We know, therefore, of no space which is not pervaded by His presence, as we know of no eternity which He inhabiteth not.

Let us, for a moment, compare and contrast finite with the infinite

and perhaps a simple illustration, contained in Figure 6, will serve the purpose.

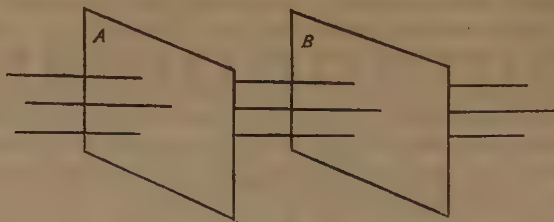

Fig. 6.

If a point (A) be assumed in a straight line which we may term specifically infinite, the line in either direction from that point will be interminable; and the two portions, one on each side of the point, may be regarded as being *in effect* equal. If, again, another point (B) be assumed in the same line, however remote from the former, the two portions, one on each side of it, may be regarded as being in effect equal; though the whole intervening distance between A and B will have been added to one of the portions into which the line was divided at the first point (A) and subtracted from the other portion. It appears, therefore, that any such distance, however great, must be regarded as nothing in comparison with a straight line interminable in only one direction. As the point assumed in the interminable line in effect divides that line into two halves, so the instantaneous present divides the eternity past from the eternity future. It does so, in so far as can be discerned, in all worlds at once; as the same plane in the figure cuts all the three straight lines which penetrate it, and which are to be regarded as interminable in both directions from the dividing plane. The present thus divides those two eternities now. Through the limit thus ever-present the current of time passes, in a metaphorical sense; and moment by moment the eternity future is transferred to the eternity past, and any portion of time however long must be regarded as nothing in comparison with either. We may thus, in some very humble measure, learn how it is that in the view of the *infinite mind* a "thousand years" should be as "one day," and one day as a thousand years.

The relations of things being, as already maintained, constituted relations; and they being also constituted in some respects alike, as appears from the comparisons of time and space, we may even reverentially proceed a step further and conclude, that as any finite, or even in some respects boundless, space is worthless, or to be regarded as of no value in comparison with the absolute infinite of space; and as, again, any finite portion of duration is also a relative zero in comparison with the absolute infinite of duration; so, also, must the highest created intelligence and lowest among men be alike worthless, or regarded as nothing in comparison with the *alone infinite one.*

Here, therefore, with humble reverence would we rest; for this discussion has led us to the consideration of great and awful themes; but here, also, with heartfelt gratitude would we bow, since He has revealed Himself, and how He may be to us the Father of Mercies.

LECTURE

ON

ARCTIC EXPLORATIONS.

By DR. I. I. HAYES,

COMMANDER OF THE LATE AMERICAN ARCTIC EXPEDITION.

I APPEAR before you, in obedience to an invitation with which I have been honored by the Secretary of the Smithsonian Institution, to give an account of my late expedition to the Arctic seas. That expedition, some of you may remember, sailed from Boston in July, 1860, and returned to the same port in October, 1861. Before passing to my narrative, a brief statement of the objects of the expedition may not be out of place.

It was my good fortune to have sailed in 1853 with the lamented Dr. Kane, as surgeon of his expedition, and I remained in that service until late in 1855. Upon my return to the United States I formed the plan of another expedition. There were many circumstances of discouragement, not least among which was an impression which then had possession of the public mind, that any further efforts toward the North Pole must be fruitless, and must involve an unjustifiable exposure of life. It was only after many endeavors that here and there the influences favorable to my design began to affect the community. The most important of these was, of course, the sanction given to my plans by those associations by whose opinions the mass of men are governed in relation to scientific matters; and it gives me pleasure that I am to-night enabled, on a public occasion like the present, to express my acknowledgments to the Smithsonian Institution for the liberal support which was rendered by it to the expedition, not only by its contribution of scientific apparatus, but through the encouragement which was given towards effecting its organization by the influence of the distinguished gentleman who is the principal executive officer of the establishment. To this approval of the Smithsonian Institution, so widely known and respected, were added that of the American Philosophical Society, the Geographical Society of New York, the Academy of Natural Sciences of Philadelphia, the American Association for the Advancement of Science, the American Academy of Arts and Sciences, the Boston Society of Natural History, and the assistance and encouragement of individuals, among whom the renowned head of the coast survey, Dr. Bache, was the most conspicuous. Yet, in spite of the efforts made in many quarters, my outfit was a very small one. My original plan embraced two vessels, one a small steamer, and the other a schooner, the latter to be placed in a convenient harbor, near the mouth of Smith strait, and the former to be used for penetrating the ice to the northward; but to obtain so large an organization as this plan involved was found to be impracti-

cable. Upon leaving Boston, July 10, 1860, my entire party numbered only fifteen persons, and we sailed in a schooner of only one hundred and thirty-three tons burden.

My purpose was to follow up the line of research opened by Dr. Kane; I allude, of course, to that of Smith strait and Kennedy channel. You will readily understand that I had no such idle purpose as was sometimes popularly attributed to me, viz: that of merely reaching the north pole of the earth as a feat of adventurous exploration.

The general object was to procure as much information as the restrictions of our voyage would allow beyond the termination of Dr. Kane's labors, and in the same direction in which they tended. The space between the point at which his personal observations ended and the North Pole is about six hundred and fifty miles, an interval sufficiently large to admit of very numerous and important observations.

Coinciding with him in the opinion that at some portion of each year there exists a large body of water about or near the Pole, I hoped to extend the evidence which he had collected on this subject as well as on many others.

It would, of course, have been a source of the highest satisfaction to have succeeded in setting at rest the question of open water, but it was by no means the sole object of the expedition.

Various questions connected with the physical condition of the earth remain to be solved by observations in high latitudes, such as the currents of the air and water; the temperature of these movable elements; the pressure of the former and the tides of the latter; the variation of gravity; the direction and intensity of the magnetic force; the aurora borealis, &c. Relative to all these it was my intention to make observations, and I trust when the results which I have obtained are discussed, as they will be, under the direction of the Smithsonian Institution, they will not disappoint the reasonable expectation I have formed of their value.

I esteemed myself fortunate in obtaining the services of Mr. August Sonntag, the able astronomer and physicist of Dr. Kane's expedition, who early volunteered to fulfil the same duties during my own, and also to aid me as second in command, and upon him were to be devolved the most important of the observations. His death soon after entering our winter harbor left me with the aid only of three young men, who were dependent almost wholly upon my instruction and supervision.

I have made these explanations in order that you may the better appreciate the difficulties which embarrassed us, and that you may not in advance be induced to overrate the unpretending collections made during my cruise; yet it is due to the truth to say also that, notwithstanding these difficulties, the zealous aid of my young associates has enabled me to return with some valuable additions to our previous stores of knowledge.

In order that you may in the outset have a clear idea of the route of the expedition, I will call your attention to the rude diagram suspended on the wall, representing the Arctic regions in circumpolar projection. The centre of the map, therefore, represents the position

of the North Pole, and, as far as known, this point of extreme northness is in the centre of a great ocean, almost mediterranean in its character, for you will observe that the shores of Greenland, America, Asia, and Europe invest it almost completely, while the islands of Nova Zembla and Spitzbergen interrupt the only broad entrance to it from the south.

It has long been supposed by physicists that this large body of water could not be frozen over, that an open sea of varying extent would be found within the ice belt which was known to invest it; and the correctness of this hypothesis seemed to be, at least partially confirmed, by the researches of the old Dutch and English voyagers, and more recently by those of Scoresby, Wrangell, and Parry. To these evidences were added the important discovery of open water by one of Dr. Kane's exploring parties to the northward of Smith strait.

The great difficulty which has been experienced in solving this interesting problem has been an inability either to push through the ice belt with a vessel, or to travel over it with sledges sufficiently far to obtain indisputable proofs.

My experience with Dr. Kane led me to believe that the chances of success were greater by the route which had been pursued by Dr. Kane than any other, and I conceived the idea of carrying a boat over the ice belt to the open water, having previously penetrated as far as practicable with a vessel.

You may remember that Dr. Kane's highest northing with his vessel was latitude 78° 37′ on the eastern side of Smith strait. It seemed to me that the chances of success would be greater if a vessel could be taken up the west coast, and from my own observations in 1854, it appeared probable that a latitude between 79° and 80° could be obtained for a winter harbor. For means of transport across the ice I relied upon dogs.

How far I was able to execute my plans, it will be my purpose to inform you in this lecture.

The schooner in which we sailed was originally built for the West India trade; she was carefully strengthened for the ice encounters by heavy beams and braces internally, and externally by a thick wooden sheathing, and by heavy iron plates over the bows and cutwater. Agreeably to my petition, her name was changed from "Spring Hill" to "United States," by act of Congress.

I will not dwell upon the details of our voyage to Greenland, which was unusually boisterous. The schooner was unavoidably so heavily laden that her deck was never more than eighteen inches above the water, and was never dry. After touching at Pröven and Upernavik, we reached, on the 21st of August, Tessuissak, the most northern of the Danish stations, in latitude 73° 40′. At all of these places we were kindly received, and the officials furnished me with every facility in their power for procuring the requisite furs and dogs for sledge travelling.

A brief description of these settlements may not be out of place in this connexion. You are all, no doubt, aware that Greenland is a possession of Denmark. It is divided into two principal districts or

inspectorates, each of which is presided over by a viceroy or royal inspector. These principal districts are known as North and South Greenland, the seat of government of the former being Godhavn, situated on the southern extremity of Disko island; and of the latter at Godhaab. Each of the inspectorates is subdivided into smaller districts, which are under the immediate control of chief traders or governors, who are directly responsible to the royal inspector. The most northern district is that of Upernavik, the seat of government of which is at the settlement or colony of that name, situated on a small island, in latitude 72° 40′. The settlements of Pröven, Tessuissak, and many others of a similar character, are comprised within that district, and are subordinate to the central authority at Upernavik. The outposts comprise generally only a trader's house and a few native tents. Upernavik has besides the government house, a missionary house, a church, and school-house, two storehouses, a shop, two blubber-houses, and about a dozen Esquimaux habitations.

The Greenland colonies are for the most part profitable to the Danish government; and they maintain the government employés and natives in comfort and abundance. The people live exclusively by hunting and fishing; and from the district of Upernavik alone, two vessels, of three hundred tons each, are annually freighted with the products of their industry and hardy skill, consisting of whale, seal, and shark oil; seal, fox, reindeer, and bear skins; eider down, walrus, and narwhal ivory; codfish, and other articles of less value.

My purpose in halting at the several stations which I have mentioned was to obtain furs and dogs for my proposed sledge travelling at the north. Having, through the kindness of the Danish officials, obtained the needed supplies, as also three Esquimaux hunters and an interpreter, we set out from Tessuissak on the 22d of August for the field of our future explorations. Our route lay thence northward through Melville bay, the usual track of the whalers. That bay was entered on the morning of the 23d of August, during a thick snow storm, with a heavy gale and a high sea following us; and without having encountered any ice we reached Cape York in fifty-five hours. This passage of the bay was remarkable.

Standing close in under Cape York, I kept a careful watch from the masthead for Esquimaux, and I soon had the gratification to see a group of them running down toward the beach, making signs to attract attention. The schooner being hove to, I went on shore in a whaleboat, and was met at the beach by an Esquimaux, whom I quickly recognized to be Hans, Dr. Kane's young hunter. Upon his expressing a desire to accompany me, I took him, together with his wife and child, on board, and again stood northward.

Beyond the parallel of the Carey islands, near which the whalers annually pass, and thence to Smith strait, our track was the same as that of Dr. Kane. The distance from the northern limit of the whale fishery to Smith strait, you will perceive, is not great, and with a fair wind we ran it in a few hours. The chief interest of our voyage commences, therefore, on the 26th of August, on which day we were a little to the northward of the position of Baffin in 1616, and Ross

in 1818, twenty miles south of Cape Alexander, the entering cape on the Greenland side of Smith strait.

The strait was entered on the 27th of August; but we were unfortunate in meeting near its mouth an ice-pack of extraordinary thickness, through which no passage could be effected. This pack trended off to the south and west, and appeared to adhere to the western coast. Our efforts to find a navigable lead were interrupted by a heavy gale which broke suddenly upon us and drove us out of the strait. The gale continued with great force for three days, during which we were a second time driven out of the strait, and, having at length sustained serious damage, we made the land and anchored.

At that place I went on shore and, from an elevation of twelve hundred feet, obtained a view to the west and north. The ice was everywhere closely packed and heavy. On the following day we were blown from our anchorage, and were much damaged against some icebergs which had drifted in with the current. It was as late as the 1st of September that we again entered the strait, again to be blown out and crippled by a sudden return of the gale. It was not until the evening of September 2d that we effected a permanent lodgment in the strait. Failing to find an opening toward the west shore, I determined to seek one higher up, near Cape Hatherton; but when among the ice off Littleton island the schooner became "beset," the iron sheathing on the bows and the cutwater were carried away, and the rudder was rendered useless. After some hours we reached a place of safety and anchored. We put to sea again on the 6th, but failing to pass Littleton island, and the temperature having fallen to 12°, when navigation was no longer safe, I was obliged to go into winter quarters in Hartstene bay, ten miles northeast of Cape Alexander, in a harbor which I have named Port Foulke, in honor of my friend William Parker Foulke, esq., of Philadelphia, who was the earliest and has been one of the most constant friends of the expedition. Subsequent observations gave our position, latitude 78° 17′ 41″, longitude 72° 30′ 57″ W., twenty miles south of the latitude of Rensselaer Harbor, (Dr. Kane's winter quarters,) and distant from it by the coast line about ninety miles.

At the time of going into winter quarters the vessel was badly crippled by frequent collisions with field ice, and by twice being driven upon icebergs. The weather was not only very boisterous from the time of our first entering the strait, but thick snow was almost continually falling. I regretted very much that we had not steam-power.

My plans of exploration being based upon reaching the west coast, and there attaining a harbor above or near latitude 79°, which I had thought practicable from personal observations made in 1854, you will perceive that our winter harbor was very unfavorable for the accomplishment of my purpose. I could not attain even as convenient a position as that of Dr. Kane, whose line of travel, being near the Greenland coast, was freed from some of the obstacles attending our passage across the strait, with dog sledge, to Grinnell Land.

Our preparations for the winter were similar to those of Dr. Kane. A house was built on shore to receive our stores, and the hold of the

vessel was converted into a room for the men. The upper deck was covered with a house made of boards, which had been brought for the purpose. The ship's company lived in health and comfort. During the autumn and winter the officers were engaged in various scientific observations.

Soon after entering our winter harbor an observatory was erected upon shore near the vessel, under the superintendence of Mr. Sonntag. It was a frame structure, covered first with canvas and then with snow, and was eight feet square. In this a fine pendulum apparatus, constructed under Mr. Sonntag's supervision by the Messrs. Bond, of Boston, after the plan of Foster's instrument, was immediately mounted, and satisfactory sets of experiments were then made by Mr. Sonntag, assisted by Mr. Radcliff. The pendulum beat nearly seconds; that is, rudely, 3,607 beats in 3,600 seconds of time. The readings were made when the knife-edge passed the zero point of the graduated arc. The interval of the readings was ten seconds, and eleven readings generally made a set. These observations were continued from September 26 until October 12. They are yet unreduced, and I am therefore unable to announce to what conclusions they lead. I may mention that experiments were made by Mr. Sonntag and Professor Bond at the Cambridge Observatory prior to the sailing of the expedition, and that the instrument will be placed in Professor Bond's hands for a repetition of the experiments at the same place.

Upon removing the pendulum apparatus, a unifilar magnetometer was mounted upon a firm support in the centre of the observatory, and the scale readings were recorded hourly every seventh day, and three times daily during the interval, from November to March. The same instrument was subsequently used for making several sets of experiments in declination, deflection, and vibration. A corresponding number of sets of experiments for the determination of dip were also made with a well-adjusted instrument. These four classes of magnetic observations were, with certain omissions, subsequently repeated at Cape Isabella on the west side of Smith strait, at Netlik in Whale sound, at Upernavik, and at Godhavn. All of these observations are yet unreduced. I should mention that the instruments were furnished to the expedition by Professor Bache, superintendent of the United States Coast Survey, under whose supervision the constants had been carefully determined, and to whom the instruments will be returned for correction.

Near the observatory a suitable shelter was erected for a number of thermometers, which were read hourly every seventh day, and three times daily in the interval. These instruments were carefully compared at every 10° of temperature down to —40°, and these records were referred to a standard which was brought home, and has been placed in the hands of the maker, Mr. Tagliabue, for further comparison. Some of the instruments were manufactured by Mr. Green, of New York, and were furnished by the Smithsonian Institution. The remainder were presented by Mr. Tagliabue. These observations were continued during our stay at Port Foulke, from September, 1860, to July, 1861. I may mention in this connexion that throughout the

cruise a bi-hourly registry of atmospheric temperature was made with a single instrument, mounted on the vessel when at sea, and on a post upon the ice when in winter harbor. A like number of barometer readings was also made and recorded. A careful record of meteorological phenomena, including direction and force of wind and general atmospheric conditions, was kept up during the cruise.

Although there has been no discussion made of these observations, yet there are some manifest general results which may interest you. Our winter was much milder than either of the winters of 1853–'54 and 1854–'55, passed by Dr. Kane at Rensselaer harbor, twenty miles further north. The weather was, unlike that experienced by Dr. Kane, generally stormy. Northeast winds, frequently very strong, prevailed—a fact at least in part accounted for by the open water which was during our stay at Port Foulke constantly visible outside of the harbor, and it was doubtless due to the same fact that we experienced a modification of temperature. March was the coldest month. It was during this month, and while absent at Rensselaer harbor, that I recorded the lowest temperature, —68° F. It is remarkable that on the same day the lowest temperature registered at Port Foulke was only —29°, and on the day previous, when I experienced a temperature of —66.5° near Rensselaer harbor, the temperature at Port Foulke was —27°.

In the autumn I made, in connexion with Mr. Sonntag, a survey of a glacier which approaches the sea through a valley opening from the head of the bay in which we wintered. This had been discovered by Dr. Kane, and by him named "My Brother John's Glacier." Its face is nearly two miles from the sea, which it is gradually approaching. With the view of determining its rate of progress, we ascended to its upper surface and carefully measured a base-line in its axis. From either end of this base-line angles were taken, connecting it with fixed objects upon the mountains on each side. Lateral stations were next established, and these were connected with the base-line, and with the before-mentioned fixed objects. The angles were repeated by me after an interval of eight months, and the result showed a downward movement of the glacier, amounting to ninety-four feet.

In October I performed a journey upon this glacier and the *mer de glace* to the eastward of it, penetrating about fifty miles into the interior. Our angle of ascent was, at first, about six degrees, decreasing gradually to from one to two degrees. The surface was at first somewhat broken and irregular, but as we advanced it became smooth and the ascent regular. Our elevation upon setting out to return was estimated at about 5,000 feet, when we were quite out of sight of land.

The sun was absent from us 130 days, and I attributed the remarkable healthfulness of our party, during that long period of darkness, in a great measure to the abundant supplies of fresh animal food which we were enabled to obtain. The reindeer, the blue and white foxes and hares were quite numerous in the immediate vicinity of Port Foulke, and through the persevering energy of our hunters a

full supply was procured before the winter set in, not only for the ship's company, but for the dogs.

With the winter, however, came serious misfortunes. A disease which has been for several years prevailing throughout all Northern Greenland broke out among the dogs, and by the middle of December all of them had died but eleven. It became then necessary to open communication with the Esquimaux of Whale sound, with the view of obtaining a new supply. It will be remembered that my plans of exploration were based entirely upon the use of dogs as a means of transportation across the ice; and from our unfavorable situation it appeared evident that with our reduced force I had not the means to prosecute my purposes with the success which I had anticipated.

Mr. Sonntag early volunteered to go to the Esquimaux for the purpose before named. His offer was accepted, and he started on the 22d of December with a sledge drawn by nine dogs, and accompanied by Hans, (Dr. Kane's young native hunter,) whom, as before stated, I had found at Cape York. This expedition was attended by an event which cast a gloom over our whole party. Mr. Sonntag lost his life in attempting to cross Whale sound. As reported to me by Hans: In the act of passing a crack which had been recently frozen over, he broke through the thin ice and became thoroughly wetted. He was assisted out of the water by his companion, but before they could reach a place of shelter, five miles distant, Mr. Sonntag was so badly frozen that he was insensible, and he died soon afterwards. The body was subsequently recovered and interred near the observatory at Port Foulke.

Hans continued southward and accomplished one of the purposes of the journey; but, in consequence of bad management and over driving, five of his team were killed, and I was left, upon his return, with only six dogs. The Esquimaux having learned through Hans of our being at Port Foulke, came to us in the spring, and from them I was enabled to obtain a sufficient number of dogs to increase my pack to about twenty; but some of them died afterwards, and I was left, finally, with two teams of seven each. With so reduced a force I became seriously apprehensive for the success of the labors which were to follow.

On the 20th of March I set out on my first journey. The object of this effort was to establish a provision depot for use during the summer, and it was successful. While absent upon this occasion I visited Rensselaer harbor, Dr. Kane's winter quarters. No vestige of the "Advance" could be discovered. She had probably drifted out to sea with the ice, and been subsequently crushed and sunk.

The preparations for the principal journey were completed early in April, and on the 4th of that month I started northward with my entire available force, comprising twelve officers and men, and fourteen dogs. Our equipment consisted of a metallic lifeboat mounted on runners, provisions for seven persons for five months, provisions for six persons and fourteen dogs for six weeks, and the necessary camp fixtures.

The open water which continued throughout the winter, within

sight of Port Foulke, extended northward in April in a narrow stream nearly to the parallel of Rensselaer harbor, and I was obliged therefore to adhere to the eastern shore, instead of pushing over to the north and west, as I had originally intended. In consequence of our forced selection of this route we encountered the same condition of hummocked ice which had embarrassed the exploring parties of Dr. Kane. The centre of the strait was crowded with ridges of broken ice, more extensive than I had ever before seen, and through these, after three weeks' trial, I found it to be impracticable to transport the boat which I had intended for the exploration of the Polar sea, and I, accordingly, with much reluctance, was obliged to send the main party back and to continue northward with two dog sledges and three companions.

The hummocks became worse as we advanced, and, although we were only forty miles, in a direct line, from the west coast of the strait, fourteen days were consumed in reaching it. We were obliged to return several times upon our track for portions of our cargo, and the severity of the labor rapidly reduced the strength of the dogs.

Our track across the strait was nearly the same as that which I had formerly made, upon my return from Grinnell Land in May, 1854, when acting under the orders of Dr. Kane. The unfavorable circumstances under which my surveys were made, during that journey, occasioned some errors upon the chart, which I was glad, on this occasion, to have opportunity to correct. As I neared the coast of Grinnell Land, it became evident that a channel or sound opened westward from Smith strait, separating Grinnell Land from the Ellesmere Land of Captain Inglefield. In the mouth of this sound are two large islands, to the northernmost of which I have given the name of Proessor A. Dallas Bache, superintendent of the United States Coast Survey, and to the other that of Professor Joseph Henry, secretary of the Smithsonian Institution, to both of which gentlemen the expedition was greatly indebted for the influence which their names gave to the support of the enterprise, and for the liberal contributions which the former made toward my outfit.

On the 12th of May I entered Kennedy channel, and following the coast as it trended nearly due north, I reached on the 16th the bay which bears the name of the renowned geographer—Carl Ritter. The roughness of the ice and the deep snow had by this time thoroughly disabled one of my companions and a portion of the dogs; and I was obliged, therefore, to continue my journey with one team and a single comrade, Mr. George F. Knorr, a young gentleman who served throughout the expedition with remarkable fidelity and spirit. After the termination of three days' severe struggling through deep snow and heavy hummocks, which were piled upon the land ice, our provisions became exhausted and we were forced to return. We had then reached latitude 81° 35′, forty miles beyond the limit of Dr. Kane's explorations on the opposite side of the channel, and further north than had ever before been attained upon land. To the highest point attained I have given the name of my very kind friend,

Professor Francis Lieber, and a remarkable peak which rose above my last camp I have named in honor of the distinguished American artist, Mr. F. E. Church.

To the northward of Cape Lieber opened a magnificent bay, which I regretted that I was not able to cross. This bay bears the name of Lady Franklin. At its head rose two bold mountain peaks, which I named Sylvia Mount and Mount Cornelius Grinnell.

To the northward were seen Cape Beechy, another high cape beyond it, which I called Cape Frederick VII, after his Majesty the King of Denmark, to whose subjects in Greenland I was indebted for many favors, and, in the far distance, I could trace the faint outlines of a magnificent headland, the most northern known land on the globe. This land I named Cape Union.

Returning upon the same track, we reached the vessel after an absence of fifty-nine days, during which time we had travelled in our various goings and comings about 1,400 miles. During this period we used for our nightly halt the snow hut of the Esquimaux.

The personal equipment of each member of the party weighed only eight pounds. Upon my return to Port Foulke only seven of my dogs remained alive, and these were so much broken that further explorations for the season, with dog sledge, were rendered impracticable.

The physical conditions observed in Kennedy channel are, perhaps, among the most important of my results. It was in that channel, and to the northward of it, as I have before observed, that Morton discovered an open sea late in June, 1854. I did not find open water, but the ice was everywhere much decayed, often being so thin that it would not bear my party; and in some places pools of water were visible. In one of these pools a flock of waterfowl, the *Uria gryllae*, were discovered. My stay in Kennedy channel was from the 12th to the 23d of May, a period of the year six weeks earlier than that at which the observations of Morton had been made; and I entertain no doubt that, could I have returned to the same locality in the latter part of June, I would have found the sea open. Indeed, everything indicated a speedy dissolution of the ice. There were some indications also that the region to the northward is annually open. I will mention one which struck me most prominently. The coast on the west side of Kennedy channel, especially where exposed to the northeast, was lined with a heavy ridge of ice, which had been forced up under the influence of great pressure. Many of the masses were as much as sixty feet in height, and they were lying high and dry upon the beach. The pressure necessary to occasion this result could not possibly be created by ice-fields moving over a narrow channel, and I believe the result to have been produced by ice-fields of great extent coming down under the influence of winds and the current from a vast open area to the northward.

The summer was passed in the conduct of such explorations and surveys as could be made in the immediate vicinity of Port Foulke. The established routine of observations was continued at the vessel, and in addition a delicate tidal apparatus was constructed, the readings of which were made to tenths of a foot, and at intervals of ten

minutes. We were joined by a tribe of Esquimaux, living on the coast between Smith strait and Cape York, and several members of the tribe continued with us until late in the summer. This singular people numbered about eighty souls. They lived in snow-houses about our harbor, and maintained themselves by hunting the walrus and seal.

The schooner, having been prepared for sea, was broken out of the ice on the 10th of July, and we sailed from our winter harbor on the 14th. After much difficulty and two trials, we reached the west coast, ten miles below Cape Isabella. That cape I was unable to pass in the vessel, but I succeeded in making its north side in a whaleboat, and from an elevation of about six hundred feet I obtained a view to the northward. In that direction the ice was everywhere unbroken; and as it did not appear probable that I could obtain for the schooner a more northern harbor, and as I had now only five dogs remaining, without means of obtaining a new supply, I abandoned the field and returned home, trusting to be able at an early day to renew the attempt with a small steamer.

While crossing over from the east to the west side of Smith strait, I followed, during a portion of the way, nearly in the track of my predecessor, Captain Inglefield, and I was struck with the accuracy with which he had exhibited upon his chart the expansion of Smith strait; and, although the geographical positions which he has given to many prominent places are slightly inaccurate, as I had subsequent occasion to determine while upon shore, yet the points of the western coast which came successively into view were so clearly his discovery, that I have replaced upon the map the names which he appended to the various localities discovered by him. The highest land visible from the mouth of the strait on the west wide, which is the eastern extremity of Bache island, bears, therefore, the name of Queen Victoria. Princess Maria bay occupies the northern side of Henry island, and Cape Albert its eastern extremity.

After leaving Whale sound I continued down the coast, and, under favorable circumstances, completed the survey of the shore, including Cadogen and Talbot inlets, as far south as Clarence Head. Here we came upon a heavy ice pack, and were obliged to hold to the eastward. Entering Whale sound, I had an excellent opportunity for delineating the shore-line of that remarkable inlet. Through a clear atmosphere I could trace the land around from the north to the south shore, thus proving the inlet to be a deep gulf, which, out of respect to the enterprising navigator who first penetrated its waters, I have designated as the Gulf of Captain Inglefield. Two prominent points of land on the northern side of the gulf were mistaken by Inglefield for islands, and I have applied to them the names which he has used. We found a colony of Esquimaux on the south side of Whale sound, and we remained long enough with them to become familiar with their habits, and to obtain some photographs of them.

During this period of the cruise every effort was made to obtain collections of specimens of natural history, and in this department, as well as in many others, I had frequent occasion to regret the smallness of my corps of workers. We, however, succeeded in obtaining

some valuable collections; these embrace dredgings from the various points visited, plants from several different localities, skins and skeletons of the principal mammals, skins of many of the Arctic birds, and a large number of skulls of Esquimaux. Our hunters captured upwards of two hundred reindeer. The walrus and seal of different varieties were also abundant. During the summer several species of waterfowl swarmed upon the islands and cliffs about the mouth of Smith strait. The most numerous of these were the little auk (*Uria alle*) and the eider duck, (*Somateria molissima*,) several hundreds of which were captured. From these sources I had no difficulty in constantly supplying our party with fresh food, and to this I attribute in a great measure our entire exemption from disease.

Leaving Whale sound, we continued southward, and completed the survey of the eastern coast of North Baffin bay, from Cape Alexander to Granville bay. This survey was made independently of the charts of my predecessors. The shore-line surveyed on the eastern side, a portion of which is new discovery, equals about 600 miles, and on the western side, between Clarence Head on the south and Cape Union on the north, about 1,300 miles. It was with regret that I turned my back upon the scene of our year's labors, and entered Melville bay. After boring through the "pack" for 150 miles, we entered the southern water, and reached Upernavik on the 14th of August, and Disco island September 1. At both these places we were kindly and hospitably received by the Danish officials. At the latter place I had the satisfaction to meet the royal inspector, Mr. Olrik. Upon reaching Godhavn, I was kindly informed by Inspector Olrik that he had received orders from his government, framed in accordance with a request made by the government of the United States, directing him to afford such aid to the expedition as was in his power; and it gives me great pleasure to be able, on an occasion like the present, to acknowledge the important services rendered to the expedition by the Danish government and its officials in Greenland, exhibiting that characteristic generosity and intelligent appreciation which have uniformly marked their actions towards all previous explorations of a similar nature.

Our voyage from Godhavn southward was very stormy, and when off Halifax such damages were suffered as required us to put into that port for repairs. Our welcome there was very cordial and highly grateful to us. The admiral of her Britannic Majesty's fleet, then in Halifax harbor, generously tendered the use of the government conveniences for repairing my crippled vessel. To the officers of her Majesty's civil government, and of the squadron and garrison, and to the citizens of Halifax, the expedition is indebted for attentions which exhibited not less a friendly feeling for men who had for so long a time been deprived of many of the comforts of civilization than respect for the flag under which our explorations had been made.

Having sailed from Boston, I considered that a proper respect for those who gave me the vessel required that I should return to that port. Leaving Halifax on the 19th of October, we arrived in Boston on the 23d, after an absence of fifteen months and thirteen days.

MEMOIR OF GEOFFROY SAINT HILAIRE.

By M. FLOURENS,

PERPETUAL SECRETARY OF THE FRENCH ACADEMY OF SCIENCES.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION BY C. A. ALEXANDER.

This Academy numbered among its members, in the last century, two brothers, one of whom left several useful treatises on botany, while the other is memorable as the first chemist who conceived a precise and practical idea respecting *affinities*. It was said with reference to the latter, by the most spiritual of the partisans of Descartes, Fontenelle, "that he had enunciated in 1718 a singular system—a table of affinities or relations of different substances in chemistry. These affinities," added Fontenelle, "gave uneasiness to some, who feared lest they should turn out to be attractions* in disguise, the more dangerous as persons of skill knew already too well how to endue them with seductive forms."

The distinction of the two brothers became a just ground of pride to their family, one of whose branches inhabited the small town of Etampes. There, in a home whose habits were still patriarchal, a grandmother was accustomed, in the long evenings, when her numerous grandchildren were grouped around her, to enchain their attention by recitals respecting her own time, in which the names of our two savans, among their relatives, did not fail perpetually to recur. To these recitals her simple admiration for renown, no less than her quality of grandmother, gave a real power; so that, on one occasion, a little boy, very delicate and sufficiently light-headed, was prompted to exclaim: "For my part, I, too, should like to be famous; but how to become so?" "By willing it strongly," replied the grandmother; "you bear the same name with those of whom I have been speaking; do as they have done." "And you will help me, grandmother?" cried the little enthusiast; an appeal which was responded to, on the part of the excellent dame, by presenting him with a copy of Plutarch's *Lives of Illustrious Men*.

It was thus that Etienne Geoffroy Saint Hilaire, born the 15th of April, 1772, was dreaming of future distinction, when his father announced that having obtained for him a scholarship in the college of Navarre, he was about to place him there. Here the poor boy was destined to find the path to fame encumbered with exercises and

* The term attraction, introduced by Newton as a fit word to designate the force which produced chemical combination, was in great favor in England, where the Newtonian philosophy was looked upon as applicable to every branch of science, while in France, on the contrary, where Descartes still reigned triumphant, attraction, the watchword of the enemy, was never heard but with dislike and suspicion.—Translator.

translations which excessively wearied him. As a scholar he had little assiduity, and manifested no taste for anything but physics.

On leaving college many advantages were offered to determine him to the church, but this destination he steadfastly declined. His father, himself an advocate, proposed jurisprudence, but a short trial ended in disgust. From law he passed to medicine, but with no better result. To the adventurous spirit which already governed him it would seem that a career more free and more remote from the beaten paths was necessary for satisfaction or success.

Urged by a secret impulse towards the sciences, Geoffroy wished to follow the higher courses of instruction, and with this view was permitted to unite himself with the students at the college of the Cardinal Lemoine. The professors of this establishment were ecclesiastics. Here the good and judicious Lhomond consecrated his life to the production of works for the instruction of youth, whose very simplicity has maintained their superiority as models of that class of compositions, and Haüy, a regent of the college, had just made that celebrated discovery in mineralogy which changed the face of the science and inscribed his own name among those of men of the highest scientific genius. Lhomond, next to childhood, loved nothing so much as plants, and Hay had been led, through his devotion to this venerable friend, to join in the same botanical pursuits. In their peaceful promenades they were now followed, though at a distance, by a young scholar, who burned with no desire so great as that of being permitted to associate himself with these distinguished men. Nor was the opportunity long deferred: a casual interview occurred, in which Lhomond and Haüy were so much touched with the ingenuous expressions of interest and respect on the part of their young interlocutor that they thenceforth admitted him to a cordial intimacy.

Under the inspiration of Haüy, Geoffroy was not backward in conceiving a passion for mineralogy. Daubenton was then delivering a course in this science at the college of France, and it was his custom, after each lecture, to interrogate his pupils. Happening one day to question Geoffroy on crystallography, he was surprised at the answers, and observed, with great good nature: "Young man, you know more about it than I do." "I am but the echo of M. Haüy," replied Geoffroy. The gratitude implied in this ingenuous avowal did not fail to excite the interest of the professor, and that interest was ripened by incidents which soon followed into a lively attachment.

It was now 1792, and Geoffroy was twenty years of age; he began his serious life amidst the distractions which then afflicted our country. All the instruction he had received had been derived from priests, and at this deplorable epoch it was sufficient to bear that title to be marked for persecution.

His former masters of the college of Navarre were arrested and imprisoned in the church of Saint Firmin, converted into a prison. Geoffroy succeeded in obtaining access to them, and urged upon them a means of escape which he had devised, but which, animated by a sentiment of common interest with their companions in misfortune, they declined adopting. Later, however, he succeeded in saving some of them, though at the peril of his own life. But

that which struck him with most consternation was the imprisonment of Haüy. Hastening as soon as he heard of it to Daubenton and other members of the Academy of Sciences, he procured in the name of that body a petition for the release of their distinguished associate. The order of enlargement was signed at ten o'clock at night, and Geoffroy instantly bore it in person to the prison. But here a new difficulty presented itself. "These great men," said Fontenelle, in speaking of the illustrious class of persons, whom none knew better than himself, "these great men are children;" and Haüy especially united to the most astonishing penetration of intellect the simplest of hearts. In the midst of such dangers as threatened him, Geoffroy found him wholly absorbed in reassorting his minerals, which had been thrown into confusion at the time of his arrest, and which he had succeeded in having brought to the prison. On no consideration would he consent to their removal at such an hour, and he was fixed, moreover, in his determination to hear mass the next morning before his departure. Accordingly, morning being come and mass duly heard, Haüy tranquilly withdrew to his humble cell and to his friend Lhomond, who, in turn, had been delivered by Tallien, one of his former pupils. But the cells they had quitted were destined to no long familiarity with their occupants: it was the eve of the terrible massacres of September.

Exhausted by violent emotions Geoffroy became ill, and retired to his family. The friends he left at Paris, though still overwhelmed by the tempest, did not cease to cherish a concern for him. "I communicated your letter to M. Lhomond," Haüy writes to him, "as soon as received, and we have never been so gay since you left us." To Daubenton, Haüy said: "Love and adopt my young deliverer;" and the injunction was observed to the letter. On the return of Geoffroy in 1793 he was received with marked affection by the now aged professor. We are at liberty to believe that, at a time of life when personal hopes are becoming extinguished, there may enter into the attachment of age for youth something of a hope to survive in the gratitude of a later generation. But the effective services of Daubenton were soon called into requisition, for the place of superintendent of the cabinet of zoology in the *Jardin des Plantes* having been left vacant by M. de Lacepede, Daubenton asked and obtained it for his young friend.

The Garden of Plants, founded by Louis XIII, enlarged by Louis XIV, and illustrated by the labors of Buffon, had become through those labors the centre of modern natural history. In 1790 Daubenton had presented to the Constituent Assembly the plan of a vast and complete institution, worthy of the ideas which had been communicated to him by the great naturalist himself. Two years later Bernardin de Saint Pierre, superintendent for a short time of the garden, called for the establishment of a menagerie, referring to the fact that Buffon had long desired to have that of Versailles, and adding that "the most useful remarks of that eloquent writer were inspired by the animals which he had himself studied, and his best-colored delineations were those of which they were the models; for the thoughts of nature," said Saint Pierre, "carry with them their

appropriate expression." In June, 1793, by a decree of the convention, the garden took the name of museum, and the instruction given there was extended to all branches of natural history, the number of chairs being at the same time raised from three to twelve. Two of the new ones were destined to zoology, one of them being given to Lamarck, while Pallas, the celebrated naturalist of the north, was designated by some for the other. Daubenton proposed Geoffroy. He was very young, it is true, but had already given evidence of a passion for labor. The paramount object with Daubenton, however, was to have an assurance that the influence of Buffon would be maintained, and the impulse he had given be carried out. "I take upon myself," he said, on seeing that Geoffroy hesitated, "the responsibility of your inexperience, and I have in your case some title to the authority of a father. Enter confidently upon the office of instruction in zoology, and may it one day be said that you have made of it a French science."

Thus we see Geoffroy a professor at the age of barely twenty-one. He has ingenuously described the embarrassment which he at first experienced: "Obliged to create everything, I acquired," he said, "the elements of natural history, in arranging and classifying the collections confided to my care." He opened, May 6, 1794, the first course of zoology which had existed in France. A fervid activity redoubled his success. The collections rapidly increased; but the menagerie imagined by Saint Pierre not being soon enough realized he improvised one. Word was brought him one morning that a leopard, a white bear, several mandrills, a panther, &c., were waiting his acceptance at the gate. The police had just prohibited the public exhibition of these animals. But the museum had as yet neither funds nor receptacle for a menagerie. What matter? Geoffroy accepts all, and establishes as he best could his coveted but terrible guests under his windows. He hastens to communicate his good fortune to his colleagues, and they, a little surprised and, it may be, alarmed, quickly provided the means of securely confining these formidable acquisitions.

About the time we speak of, the venerable M. Tessier, who had sought refuge in Normandy from the violence of the revolution, announced to his friends from the place of his retreat that he had just made *the best of his discoveries*, and called upon them to open the career of the sciences to *another Delambre*. His letter was accompanied by some memoirs drawn up by his protegé. These were referred to Geoffroy, who, struck with enthusiasm at their perusal, and yielding to a generous inspiration, wrote immediately to their author: "Come and fulfil among us the part of a Linnæus—of another lawgiver of natural history." It would be impossible to characterize Cuvier more happily.

On the arrival of the *new Linnæus*, Geoffroy devoted himself without reserve to his interests. To admire, to praise, and to enjoy the success of others, was one of the felicities of his life. Having a lodge at the museum, he shared it with Cuvier, and threw open to him all the collections. A mutual devotion to study naturally united their labors, among the first results of which, two may be here no-

ticed. Of one, the object was the *classification of mammifers*—and here the skilfully-sustained idea of the *subordination of characters*, which was the great resource of Cuvier, predominates. The other was the history of the *makis*, or apes of Madagascar; and in this we already discern traces of the *unity of composition*,* to which Geoffroy has subjected all comparative anatomy. It was easy to foresee that two intellects, whose philosophic processes were so different, would not be long in finding separate paths. Meanwhile their confiding friendship rendered them perfectly happy. In a science till then so little cultivated each result at which they arrived was new to all the world. How often have we heard both in after years recall with complacency that early and enchanted time when, in the words of one of them, (Cuvier,) "they never breakfasted without having first made a discovery." The truth is, so little was then known of the structure of animals that it was almost impossible to make the dissection of one without perceiving some new organic details.

It was in vain that the jealous friends of Geoffroy expostulated that he was laying himself too open, and preparing for himself a designing rival, perhaps a master. The effect which these representations produced on him has been recorded by Cuvier, in terms which will enure to the lasting honor of Geoffroy. "They endeavored," he says, "to make him believe that he ought not to befriend me, that by and by I should have the sole credit of our labors; but this excellent young man declared to me, with entire earnestness of heart, that such advice made him unhappy, and that nothing would ever have the power to change his conduct towards me."

The labors of Geoffroy were conducting him at a rapid pace towards the Institute, when, at the commencement of 1798, Berthollet came to say to him: "Come with Monge and me; we will be companions; Bonaparte is to be our general." Whither were they going? It was what no one knew. In this very mystery there was one attraction the more for Geoffroy. He embarked, and his lucky star conducted him to Egypt.

From the moment of his arrival Geoffroy was seized with the desire of exploring everything. He rummages the soil, the tombs, the ruins. He frequents the catacombs, those gloomy and antique museums, where the Egyptians of old collected the remains of creatures which were their cotemporaries, and laid them up, as it were, a deposit for the study of after times.

Geoffroy brought us from Egypt specimens of the crocodile and the ibis, entire and perfectly preserved, skeletons of the ichneumon, the ox, &c. These animals, which lived two or three thousand years ago, compared with those of to-day are found in no respect to differ from them. Thus we owe to him the strongest proof that could be given

* "It seems that nature has shut herself up within certain limits, and has formed all living beings on one sole plan, essentially the same in principle, but varied in a thousand ways in all the accessory parts. Thus, in each class of animals, the forms, however varied, all result at bottom from organs common to all; nature has forbidden herself the employment of new ones."—*Dissertation sur les Makis.*—*Magasin Encyclopédique*, t. vii, p. 20, 1796.

of the fixedness of species, an important fact, which he was destined afterwards to dispute.

A special interest attaches to the human mummies which he collected. Volney had just revived the idea that the people of ancient Egypt belonged to the negro race, and considered the question determined by one or two phrases of certain historians, who say, in effect, that the skin of the Egyptians was black. Volney is mistaken. The color of the skin is here not the decisive feature; it is the form of the skull, and the skull of the mummies leaves not a doubt. Whatever may have been their tint, the celebrated people, among whom all tradition places the first cradle of the sciences, pertained to the same race of men with ourselves.

Voltaire has styled Herodotus, "The father of history, who has bequeathed us so many fables." Geoffroy seems to have taken upon himself the task of justifying, as far as the naturalist is concerned, whatever is most marvellous in the honest statements of the first of observers. Herodotus tells us, for instance, that the crocodile is, of all animals, that which is proportionably the smallest at first and largest at full size; the only one whose upper jaw is moveable upon the lower; the only one which has no tongue, &c.; and all this may be said to be true, if due allowance be made for the inaccurate language of a writer who is no man of science and makes no pretensions to be so. The crocodile, which attains as much as seventeen cubits in length, springs from an egg scarcely seventeen lines long. Its upper jaw does not move on the skull, but this jaw and the skull, being united, move on the lower one. It has a tongue, but so short that it can make no use of it. The historian goes on to say that when the crocodile lays its head on the bank of the Nile to inhale air. a small bird enters with confidence into the redoubtable orifice of its throat and shelters there in safety, while the crocodile does it no hurt nor makes even a single movement for fear of alarming its little guest. This Geoffroy had witnessed: a minute bird (the *petit pluvier* of Buffon) does, in fact, enter the throat of the crocodile, and exercises with entire impunity the functions of relieving the animal of the insects which attach themselves to its palate and which the shortness of its tongue disables it from removing by any effort of its own.

From the time of his arrival in Egypt Geoffroy had applied himself to an attentive study of the fishes of the Nile. Among those which he most wished to examine was the *Silurus electricus*, which the Arabs, in their language, not unaptly call the *thunderbolt*. Though he had often inquired for this fish, he was able to obtain a specimen only a few days before the capitulation of Alexandria, and it was amidst the perils of the siege, whilst bullets were whistling around his ears, that he might have been seen, like another Archimedes, absorbed in the meditation of problems of equal interest. His research was directed to that secret bond which connects electricity with the principle of life. But Geoffroy, whatever his passion for knowledge, found, as others have done, that the impenetrable mystery of life is, like the Isis of Egypt, covered with a veil which no mortal can raise. It was in the midst of these preoccupations that he learned that, by

an article of this unfortunate capitulation, the French savans were to be despoiled of the fruits of the researches from which they promised themselves so much honor. Fired with indignation, he proposed to his colleagues to employ the time which remained before the execution of the treaty in burning their collections. This sacrifice had been determined on, when the English agent, struck with respect, paused before so energetic a resolution and the article was erased.

After four years absence Geoffroy returned from Egypt, "loaded," as Fontenelle said of Tournefort returning from Greece, "with the spoils of the East." As if inspired with new ardor for study, we find his re-entrance into the museum marked by even multiplied labors in the two sciences which have occupied his life, zoology and comparative anatomy. In the former, it is the equally accurate and intuitive perception of the analogy of natural beings, what he himself called the *instinct of affinities*, which peculiarly distinguishes him. It was this instinct which guided him to a higher law of method, by virtue of which, in conjunction with the principle of the *subordination of organs*, he established that of *changeable subordinations;* the same characteristic which predominates in one group being possibly but a subordinate characteristic in another. Thus the teeth, a dominant characteristic in the group of carnivorous animals, form but a subordinate one in the group of bats, marsupials, &c., and, if followed out, would break up all the relations which constitute the family in the latter group. Viewing method thus under a new aspect, Geoffroy finds in general classification no other merit than the negative one of leaving the natural and direct relationship of species unbroken. Thus regarded, method is no longer a series of divisions and interruptions, but a chain of relations which mutually call for and adapt themselves to one another. In the time of Linnæus, it was the wide intervals, the marked differences which engaged the attention of naturalists, because the number of known species was then inconsiderable. In proportion as that number increased, (and it increases continually,) marked differences become effaced, the intermediate shades melt into one another and the wide intervals are filled up. The unity of the animal kingdom stands revealed, and we comprehend the profound expression of Buffon, that "shadings (*les nuances*) are the great work of nature."

If, in zoology, the predominant idea of Geoffroy was the unity of the animal kingdom, in comparative anatomy it was his constant aim to prove that unity by the unity of composition. Thus all his researches in this line tended to the discovery of analogies. Beginning with the comparative study of the members, he passed from thence to that of the skull. The skull of the crocodile and of fishes is composed of twenty-five or twenty-six bones, while that of birds and adult quadrupeds has but eight or ten. It was necessary to reconcile this apparent diversity with the theory of unity, and one of those happy inspirations which fall only to the lot of genius led Geoffroy to examine the skull of the fœtus in birds and quadrupeds. Here all the primitive bones, which at a later period will unite to form a com-

plex structure, are still separate, and the problem is resolved: the number of bones is found to be everywhere the same.

These ingenious investigations, which laid the foundation of entirely new views in science, date from the year 1807. It was in that year that Geoffroy, a place having become vacant in the academy, offered himself as a candidate. On this occasion having submitted some of his memoirs to the celebrated geometer Lagrange, he was asked by the latter what he thought of his competitor? "We know that he is an accomplished entomologist; but is he a Reaumur or Fabricius?" "A Fabricius," replied Geoffroy. "Yet for my part, young man," rejoined Lagrange, "I prefer a few such pages as you have recently read before the academy to whole volumes after the manner of Fabricius." Cuvier, in congratulating him on his nomination, which took place 14th September of the above year, remarked to him, "I am the more gratified because I had reproached myself with occupying a place which rightfully belonged to you." This Geoffroy often pleased himself with recalling, ingenuously adding, that the expressions of Cuvier surprised him, as the idea had never occurred to him that his own nomination could possibly precede that of his distinguished friend.

In 1810 Geoffroy proceeded to Portugal to execute a commission of the emperor, who, wishing that all the remarkable objects in foreign museums should be represented in those of France, sent him to visit that of Lisbon, which abounded especially in rare and valuable specimens from Brazil. Before setting out, he provided himself with all that could be spared from our own galleries, and though invested with full powers as a commissioner, in a country occupied by our troops, he took nothing except on the terms of an exchange. This generous proceeding smoothed all difficulties, and he had the satisfaction, not only of returning with ample collections, but of having gained for his own country a new title to the respect of foreign nations.

In his whole scientific career, a career at once so laborious and enthusiastic, Geoffroy may be said to have realized the idea of a celebrated writer, "that he who sees one truth thoroughly, sees always an infinity of others, and that he who should see all truths would at last see but one." To date from the memoir which opened to him the doors of the academy, his whole thoughts, meditations, and researches were bent on one object: the study of the *unity of composition* in animals. This led him to style himself in the words of Saint Augustine: *homo unius libri*, the man of a single book. It was in 1818, that he ventured finally to assign this unity of composition as the first and supreme law of the whole animal kingdom, and that he gave to the world the work since become so well known under the title of the theory of analogues or anatomical philosophy.*

* The exact title of this work is: *Philosophie Anatomique:—Des organes respiratoires sous le rapport de la determination et de l'identité de leur pieces osseuses.* It consists of four memoirs, preceded by a preliminary discourse on the author's theory. "The views," he says, "to which we are conducted by the presentiment that we shall always find in each family the organic parts which we have observed in another, are what I have embraced in this work under the denomination of the Theory of Analogues."

Buffon had already remarked that there exists a constant conformity, a sustained design, a hidden resemblance, more wonderful than the apparent diversities: "It would seem," he eloquently said, "that the Supreme Being had chosen to employ but one idea, and at the same time to vary it in all possible ways, to the end that man might equally admire the magnificence of the execution and the simplicity of the design." This unity of plan or idea was seen, after Buffon, by Vicq-d'Azyr and by Camper: "Nature," says the former, "seems always to work after a primitive and general pattern, from which she never departs without regret, and hence the two characters which appear to be impressed on all beings, that of constancy in the type and variety in the modifications." Geoffroy, in turn, became impressed with these views, but in a manner so original and profound as to entitle him to be considered the author of a new science of philosophical anatomy, unknown to all who had preceded him.

The great and proper merit of Geoffroy is to have sought the means of study and comparison in the primitive and constitutive elements of the organs. Before him, it was the *adult state* which had been studied, where we find only the composite result: in the *fœtal state*, to which he directed his researches, the primitive nucleus, the simple fact, stands revealed, destined in all cases to be the subject of the same fixed and determinate laws of development, complication, and relative position.* This unity of law is the last and highest proof of the unity of design or idea, and thus the profoundest science passes naturally into the most elevated philosophy. When Newton, at the close of his immortal labors, recognized the fact that each globe or world is subjected, not to its own proper or distinctive law, but all to one sole and common law, he recorded the expressions so worthy the admiration of every reflective mind: "It is certain that, as all bears the impress of one sole design, all must be subject to one only and the same Being."

It was impossible that Geoffroy should have made the general idea of the unity of *composition* in animals the subject of such exhaustive meditation without having had his attention directed to those particular cases of anomalous or incomplete development which in ages

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* I. *Law of development.* For every organ there is a maximum and a minimum of development; and no organ passes abruptly from one of these conditions to the other. *A fortiori*, no organ disappears abruptly. The *cetacea*, which have no hinder members, have still a small bone, the last vestige of these members, hidden under the skin; the *carnivora*, which have no clavicle, have a small bone, its last vestige, suspended in the flesh, &c.

II. *Law of complication*, or, more precisely, of *compensation.* When a part is developed beyond proportion, it is usually seen that some other part is diminished or even effaced. Among reptiles, the frog, which has members, has not ribs; serpents which have many ribs, have no members, &c.

III. *Law of relative position*, or *principle of connexions.* All parts always preserve, in relation to one another, the same place: the skull in relation to the vertebræ, the vertebræ in relation to the members, all parts of the members, each the same place in its relation to other parts, &c.

The principle of connexions is the chief, and, if I may say so, the operative principle of M. Geoffroy's theory: it is this which enables him to recognize, which unmasks to him each part through all the mutations of *form*, of *volume*, of *use*, &c. These may, and, in effect, do all change; but one thing, the *position*, is invariable. "An organ," says Geoffroy, "is altered, atrophied, annihilated, sooner than transposed."

of total ignorance passed under the name of *monstrosities.* In the last century the question regarding monsters had been the subject of a long debate between two members of the academy, Winslow and Lemery, of whom the first may be said to have completed in the 18th century the anatomy of the human body, commenced by Vesalius in the 16th; the second was the son of that Nicholas Lemery whom Mairan styled the Descartes of chemistry. Lemery was himself a Cartesian, Winslow altogether a Leibnitzian: the former held that there were no monsters except from accidental and mechanical causes; the latter simply supposed the pre-existence of monsters, as Leibnitz had supposed the pre-existence of beings. The dispute lasted for ten years, until the death of Lemery in 1743; and, as was remarked by Fontenelle, "it was not possible, as things went on, that it could be terminated otherwise than by the death of one of the disputants, for at every new explanation offered by Lemery, Winslow launched at him a new monster." It was reserved for Geoffroy to carry the theory of *accidental causes* to a point of such clear and incontestable evidence that it is no longer feasible to seek for any other. And this, by virtue of two principles which suffice to explain everything, the principle of *arrest of development* and that of *attraction of similar parts*,* principles educed as well from his own ideas as from the concurrent labors of the eminent anatomist, Serres, who was the friend of his whole life. The result of the long and persistent inquiries of Geoffroy on this subject may be summed up in the expression: there are no monsters; there are merely accidental and secondary anomalies.

In the first volume of his *Philosophie Anatomique*, wherein he laid the foundations of his system, the principle of *unity of composition* is applied, in a direct manner at least, only to vertebrate animals; and, confined within these limits, this important principle could not be

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* By means of the first of these principles Geoffroy explains all monsters by defect; by the second all double monsters. The parts which are wanting, or of which there is only a rudiment or vestige, are abortive; that is, parts arrested in their development. When two fœtuses or germs unite, so as to produce the *double* monstrosity, they always unite by *similar parts*, by similar tissues or organs; the heart of one fœtus uniting with the heart of another, the brain with the brain, the half of the pelvis of one with the half of that of the other, &c. This attraction of similar parts received from Geoffroy the more abstract name of attraction of self for self, (*soi pour soi,*) and was regarded by him as a general law of nature, though we here consider it only as a physiological principle. Lemery had already said: "A reflection is forced upon us by a fact often repeated in the subjects before us, the fact that all destructions and regenerations of parts which have there taken place have only done so through the reciprocal action of two similar parts. The stomach, for instance, having effected with another stomach what it could not do with a liver, is there not room to conjecture that homogeneity of substance permits in the first case what heterogeneity prevents in the second?"—(*Mem de l'Academie des Sciences, p.* 351, 354, *an.* 1740.)

In 1822 Geoffroy collected his early memoirs on the subject in a volume entitled *Philosophie Anatomique: Des Monstrussities Humaines*, and in 1827 published in the *Dictionnaire Classique d'Histoire Naturelle* an article, *Considerations Generales sur les Monstres*, which contains the most precise and elaborate digest of his theories. His son, Isidore Geoffroy, connecting his own studies with those of his father, published in 1832 the most important and complete work on this subject which there is room to desire, entitled *Traité de Teratologie*, or a general and special history of the anomalies of organization.—(See also *Recherches d'Anatomie Transcendante*, &c., par M. Serres—Theory of Growth and Deformity applied to explain the Organization of Ritta-Christina; Paris, 1833. Tr.)

contested. In 1820 he proposed to extend it to articulate animals,* and opposition at once declared itself. Cuvier let fall some expressions of impatience and disapprobation. In 1830 he proceeded to include the mollusks within the same principle, and the veil was rent which had thus far covered the dissatisfaction of Cuvier. The first claim of Cuvier to renown had consisted in a reformation of the entire classification of the animal kingdom. He excelled in disentangling, in description, in characterizing with precision both things and ideas. Almost all the animals without vertebræ had been confounded together. It was he who separated the zoophytes from the mollusks, the mollusks from the articulata, and these three groups established, he had made a fourth group of all the vertebrate animals united in one bond. He had thus four schemes or types essentially distinct, and the classification of the animal kingdom, regarded in its great masses, might be considered as fixed. But now this symmetrical arrangement, the fruit of so faultless an application of method, seemed every day more and more menaced by the progress of the ideas of Geoffroy, who, for his part, would see but one scheme and a single type.

The discussion was introduced into the Academy of Sciences, and never did a keener controversy take place between two adversaries more resolute and unyielding, better fortified with resources for a combat long foreseen, and, if the expression may be used, more learnedly prepared not to agree with one another. Between the two, moreover, there was a characteristic difference: in one there was vast capacity, guided by a cold and luminous reason; in the other glowing enthusiasm, heightened by flashes of genius. Outside of the academy and even of France the disturbance was propagated to all countries where men thought upon such subjects. We might have imagined ourselves transported to those ancient times when the sects of philosophy agitated states by the shock of their opinions. The world, in effect, took sides. The more austere and regular thinkers, those who were disposed to regard the rigorous logic of science with more favor than its rapid intuitions, took part with Cuvier; the hardier spirits ranged themselves on the side of Geoffroy. From the bosom of Germany the now aged Goethe sent him an applauding suffrage. Indeed, so warmly was the interest of the question felt by Goethe that, meeting a friend in July, 1830, he exclaimed, "You have heard the news from Paris; what think you of this great event? The volcano has burst forth, and all is in flames." "It is, indeed, a fearful account," replied the other, "and from the point which things have reached, we may well expect the expulsion of the royal family." "What! talk you of royal families?" rejoined Goethe. "I am speaking of the session of the Academy of Sciences; it is there that the fact of real

* See his *Memoirs sur un squelette chez les Insectes*, (read before the Academy January 3, 1820; *Sur quelques Règles Fondamentales de Philosophie Naturelle*, January 17, 1820; *Sur une Colonne Vertebrale, &c., dans les Crustacies*, February 21, 1820.

importance has transpired, and the result is a revolution in the human intellect."*

And in effect, though the direct discussion on this occasion might seem to turn upon the number or relative position of certain organs, the conflict was essentially that of two philosophies which will forever dispute the ascendency: the philosophy of specific facts and that of general ideas. In these imposing problems it will always constitute a strong attraction to the human mind that it seems ever on the point of arriving at a term which forever flies before it. The strife between the two systems or methods did not commence with Aristotle and Plato, nor will it terminate with Cuvier and Geoffroy. Even considered by itself, the question of the resemblance or the difference of creatures is one without limits. The more animals are studied the more are we struck with their diversities, but at the same time the more do we discover of their resemblances. This truth, which did not escape the penetration of Aristotle, led him to apply to animals the name of analogues, or beings similar but diversified. The discussion before the academy produced the usual effect; the two adversaries withdrew, each somewhat more confirmed in his own views. Geoffroy gave to the public a general view of his opinions under the title of *Principes philosophiques de l'unité de composition;* and Cuvier announced that he should publish a summary of his under the title *De la varieté de composition dans les animaux.*

These two personages, by the brilliancy and force of their ideas, by the very opposition of their doctrines, mark a new and memorable epoch in science. When Cuvier, in the last year of the last century, published his *Leçons d'anatomie comparée*, the admiration excited was without bounds. The grandeur of the results, the comprehensiveness of principles, equally certain and unexpected, struck every one with astonishment. The same hand which had reared the science of *comparative anatomy* founded one still more surprising, the science of lost existences. At the voice of genius the earth seemed once more repeopled with its primitive inhabitants.

To these general and transcendent views succeeded the study of

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* Apart from its scientific import, Goethe had both personal and national grounds for the extraordinary interest in the subject which drew from him the manifestation here mentioned. In a paper which he published in reference to the discussion in the French Academy, (Sämmtliche Werke; Philadelphia, 1856: Band 6, seite 471,) he takes occasion to relate that the appearance of the first volume of Buffon's HISTOIRE NATURELLE occurred in the same year with his own birth, 1749; and the successive volumes becoming the objects of his earliest interest, awakened in him a love for the study of natural objects, which soon led him into the field of controversy as well as of observation. On the other hand, while his fellow-countrymen, Camper, Kielmeyer, Meckel, Oken, Spix, Tiedemann, &c., are cited with respect by Geoffroy, and recognized as allies in the attempt to establish the unity of the animal kingdom, Cuvier, as Goethe complains, had publicly asserted that "behind this theory of analogies there lurked, though in a confused manner, another old and exploded theory which certain *Germans* were trying to revive in order to favor the pantheistical system which they called natural philosophy." This charge Goethe of course repels, alleging that "the two processes of reasoning (Denkweise) from the universal to the particular, and from the particular to the universal, are equally indispensable; and that, notwithstanding their habitual antagonism, the more vivaciously these mental functions, like in and out breathing, are carried on together, the better will be the result for science and its friends."—Tr.

details. Facts were no more than facts, and the harvest of grand ideas appeared to have been gathered. It was at this point that a new genius arose, bold, original, and penetrating. The whole science becomes at once reanimated; the fact is vivified by the idea; conjecture unites itself with the most exact observation. The new adventurer overleaps the recognized boundaries, and, beyond those boundaries, establishes a new science, to which he communicates something essentially and pointedly his own: his daring, his love of abstract and hazardous combinations, his sudden and unforeseen intuitions. The renown of Geoffroy will consist in his having laid the foundation of the profound science of the intimate nature of beings, *philosophic anatomy*.

To his principal ideas on the laws of animal organization, Geoffroy, towards the latter years of his life, added some others which are but accessory in relation to the former. These were his views on the *mutability* of species, on the *filiation* of existing species with lost ones, and that other *filiation* of æras and species which would make of all beings only successive stages of one and the same being. These views, in which, it must be confessed, the real does not sufficiently disengage itself from the ideal, are not peculiar to Geoffroy. They form no part of that noble assemblage of new and fundamental laws which constitute his proper doctrine and to which his name will always be attached.

From the first institution of the faculty of sciences, Geoffroy had been called to one of its chairs of anatomy and general zoology. Here it was that he indulged himself in the development of his philosophic ideas. In the chair which he filled at the museum for nearly half a century, his principal object was the study of the *relations of beings*, a study which he carried so far that it is to be regretted he has left nothing written upon it.

What gave most force to the lessons of Geoffroy was his enthusiastic admiration for the sciences. He would not admit that bounds could be prescribed to their progress, but expected and required of them the ever-renewed emotions which constituted the excitement and charm of his life. In familiar intercourse the inspirations of a rich and rapid imagination imparted to his conversation not only fertility of ideas but a certain elasticity of thought, whose manifestations were often as striking as unexpected. He was too much indebted, indeed, to his imagination not to give it the rein; at times perhaps too freely; for to this source might be imputed the few moments of estrangement which shadowed the course of his friendships. Yet, even at such moments, it was but necessary to address one's self to his heart to find all those traits of youth restored which governed, as we have seen, his earlier intercourse with Cuvier. "The excellent young man," as Cuvier then characterized him, survived to the last; always under the dominion of some generous impulse, always ready to spend himself, and, what is still more rare, to efface himself, in the service of another; always confiding and open with his friends, as in the first stages of life. Nor were the acts of generosity and devotion with which his life was filled always unattended with personal danger. We have seen him risking his

safety at St. Firmin to effect the deliverance of his former teachers, and in 1793 he sheltered under his roof the unfortunate Roucher, author of the poem of "The Months." Again, in 1830, the same roof became the asylum of de Quelen, archbishop of Paris, a fugitive at the time from popular menace and pursuit. To a friend who pointed out to him the danger which he incurred by this new act of generosity, he replied, "Bear with me this one time more; you know I am an old offender in this way."

He allowed himself no relaxation from his labors, except in the tender intercourse of his family. To this no one could surrender himself with more perfect abandonment and relish. He had the satisfaction of early recognizing in his son a noble intelligence, to which he might securely confide the care of his fame and the maintenance of his doctrines. "Judge," said he, one day to a friend, "whether I ought not to be happy. Behold here the most cherished treasures of my son;" and so saying he opened a closet in which the young boy had religiously collected every thing which had been written concerning his father's labors.

Voltaire, in a celebrated verse, had boldly proclaimed of himself—

"Yes, I love glory, and I dare avow it."

With an equal love of celebrity Geoffroy was as little disposed to dissemble it. Perhaps no one ever aspired to renown more frankly and openly, and it has been given to few solely devoted to the sciences to obtain a greater share of it. His views, his principles, even his language, have penetrated everywhere, and left everywhere the impress of his influence. All the celebrated academies numbered him among their members. Learned strangers made the pilgrimage of Paris with the sole purpose of seeing him. Our own provinces and the neighboring nations, especially Germany, that home of Goethe, that country of the Okens, the Caruses, and the Spixes, sent every year a throng of young neophytes who desired to hear and to know this chief of a great school.

In a retired corner of the museum is a little hermitage where Daubenton, a half century before, had installed Geoffroy. It was in this domicile, endeared to him by so many recollections, that the latter, when advanced in years, saw himself surrounded by disciples who ascribed to him the same infallibility which he himself accorded to the sciences, and in this regard his belief well entitled him to be the head of a school of believers. Towards the close of his life he was affected with total blindness, but this was attended with many alleviations. His latter days were soothed by the caresses of two young children, for whom he fondly anticipated a career like his own, and the pious cares of a daughter, in whom his own qualities were mirrored, surrounded him with tender assiduities. The noble companion of his life survived to press his faltering hands, the mother of a son who was the solace and glory of his old age.

Geoffroy expired tranquilly June 19, 1844. This bold investigator of nature, who had cast upon her mysteries so penetrating a glance, in receiving the last farewell of a beloved child, said to her with calmness: "Be assured, my daughter, we shall meet again!"

THE SUN: ITS CHEMICAL ANALYSIS,

ACCORDING TO

THE RECENT DISCOVERIES OF M.M. KIRCHOFF AND BUNSEN.

BY AUGUSTE LAUGEL.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION FROM THE "REVUE DES DEUX MONDES," PARIS, JANUARY 15, 1862.

SCIENCE has just succeeded in transcending one of those intervals which scarcely the most daring cosmogony or unbridled fancy had ventured to traverse. Astronomy had weighed and measured the sun; chemistry, aided by physics, to-day makes an analysis of it. It says to us, "The solar atmosphere comprises, in the state of vapor, a great number of the substances which compose our planet, iron, the metals which enter into the composition of our alkalies and earth, potassium, sodium, strontium, calcium, barium; it contains chrome, nickel, copper, and zinc; on the other hand, neither gold, nor silver, nor mercury, nor aluminum, nor tin, nor lead, nor antimony, nor arsenic, nor silicium, at least in notable quantities, are to be found in it. Among the metals at once telluric and solar are to be included *cœsium* and *rubidium*, metals yesterday unknown, which had escaped all the processes of ordinary chemical analysis." These affirmations of science are so surprising that we might be tempted at first to consign them, without examination, to the reveries of a Swift, a moralist turned chemist, or the imaginings of some new Micromegas; but the labors of M.M. Kirchoff and Bunsen present not the slightest trace of extravagance. We have here no romance, more or less ingenious, where the plurality of habitable worlds is discussed, where hypotheses are unceremoniously mingled with facts, cosmic mysteries with the realities of the sublunary world. The discoveries of the two German savans are founded on the most rigorous observations, and deserve to be classed among the most admirable acquisitions of the positive sciences. Their method, at the same time that it has to some extent given the means of exploring the sun from a distance, has furnished to chemical analysis a process of investigation of an unheard of, almost miraculous, delicacy. We may boldly affirm that by this method mineralogy may be revived and renovated, that chemistry will enlarge its domain and be able to master problems heretofore irresolvable. Meanwhile the capital result of these admirable researches—the one which most interests the philosophy of nature—is already attained: the identity of the materials which compose the sun and the earth has been demonstrated. The chemical unity of our planetary system has been placed beyond dispute.

This is not a discovery to which we can be indifferent. Man had long

regarded as the centre of the cosmos the little eccentric ball which carries him; he thought that between himself and mineral or organic nature there was no bond or relationship. We know now that materially we differ in nothing from all that surrounds us; we are living laboratories through which circulate all terrestrial substances. At this moment it is demonstrated that these terrestrial substances occupy our whole planetary system. We were already united with the animal, the plant, the water, the dust, with the infinitely little; we are now united with the sun, with the infinitely great.

The alchemists had instinctively suspected the unity of chemical composition of the planetary system; at least, they had established, in virtue of certain mystic ideas, relations between the different metals and the bodies which revolve around the sun; they never forgot the stars in studying the *great problem* of the transmutation of metals. We must needs be indulgent towards these aberrations of the human intellect, for truth itself has at times such an aspect of strangeness and magic as to affect the mind with doubt and bewilderment. The imagination must be poor, indeed, to look with indifference on the experiments of M.M. Kirchoff and Bunsen. The material of the sun analyzed in the light which it transmits to us! The most subtle and most inaccessible of things subjected to the most precise appreciation! Is there not here something to call forth astonishment and admiration? Into his darkened chamber the physicist admits a solar ray; there, tranquilly and at his ease, he compares his artificial lights with that light which inundates the universe, which pours life and heat to distances which thought cannot measure, and from this comparison he succeeds in deducing a complete theory of the physical and chemical constitution of the sun, of the grand phenomena of which that star is the theatre, of the spots which astronomers descry in it.

The recent labors of M.M. Kirchoff and Bunsen are based on an analysis of the solar light. To analyze is to decompose; but we can only decompose that which is not simple. The solar light in effect is not a simple light; a ray, however attenuate we suppose it, traversing the eye of a needle, or some crevice incomparably more narrow, is not homogeneous; it is composed of an infinity of differently colored rays, which, united in a pencil, constitute what we call white light. We have but to cast our eyes around to comprehend that the light of the sun comprises all colors; the diversified world which surrounds us is not a sketch, it is a picture. If the solar beam were simple, all objects would appear to us with the simple contrasts of light and shadow, as in photographs: the greatest charm of nature would be destroyed. The color does not belong to the objects, for when the sun has disappeared beneath the horizon all tints vanish in the same darkness.

Is there not a means of decomposing this ray of light, which we just now imagined as traversing an aperture, in such a way as to separate the different rays that compose it? Nothing is easier; it suffices to make it traverse a prism of glass by which the different rays are unequally refracted. This phenomenon of refraction, which

is produced whenever the luminous rays pass from one substance into another, explains all that play of light which we witness in the water, in the atmosphere, in all transparent mediums. We owe to Newton the first scientific explanation of it.

Let us suppose ourselves in a chamber entirely darkened, into which light enters only by an extremely narrow slit made in a shutter. Let a glass prism be presented in the line which the entering sheet of rays is traversing, and a leaf of paper be placed at a distance of some feet beyond and opposite the prism. The different rays which compose the white light are not refracted in the same degree in passing from the air into the glass, nor again in quitting the glass to traverse the air anew: consequently, in place of a luminous white line, we shall see on the paper a rectangle covered with differently colored bands. Newton distinguished therein seven principal colors: violet, indigo, blue, green, yellow, orange, and red; in reality, the tints pass into one another by an insensible and harmonious transition. To this expansion of the luminous beam has been given the name of *solar spectrum*, though with little justice, for nothing spectral can attach itself in idea to that beautiful sheet of light, whose tones the richest pallet would fail to reproduce. The colored bands of the rainbow are merely a solar spectrum, pale and much weakened, produced by the refraction of the rays in the minute drops of rain; the play of light which is so fine in soap bubbles better represents the brilliancy of the spectrum in the darkened chamber.

So long as curiosity was limited to the simple effects produced by the interposition of the prism and the reception of the refracted rays on a sheet of paper or other white surface, there was nothing seen in the spectrum but the seven elementary colors, without further discoveries; but the spectrum, like every luminous object, may be studied with magnifying optical instruments, and it was by exploring it in this way that, about 1814, the German savant Frauenhofer remarked some singular properties, whose discovery will immortalize his name. The spectrum, as we have seen, is formed of an infinite number of bands of different tints united together; the flag, as it were, of nature, not *tricolore*, but *omnicolore;* and among these colored parallel zones Frauenhofer was the first to perceive bands or rather lines of black, not only towards the two extremities of the spectrum, where the light is merged in the surrounding obscurity, but in the most brilliant parts and in all the colors. He recognized these lines as having the same invariable place in the spectrum, and since that time they have preserved the alphabetic name which he assigned them: we still say the line A, B, or C, of Frauenhofer, and in thus speaking physicists know at once in what part of the spectrum these rays are found.

With more delicate instruments and more perfect prisms, there have been observed in the spectrum many more dark lines than Frauenhofer had indicated. In 1860, the English philosopher Sir David Brewster, to whom optics owes so many happy discoveries, presented a drawing of the spectrum crossed by a multitude of these lines, and M. Kirchoff has employed, in the course of the observations just completed, so delicate an apparatus that, to use his own expression,

several thousands of dark lines are distinguishable in the solar spectrum.

A phenomenon having been once recognized, it remains for reason to interpret it. How are we to understand this fact, that the light includes obscure spaces, and that when the white ray spreads out into the iridescent band, there should be vacuities in the series of colored rays? Each of these rays has a power of refraction proper to itself; it is by virtue, indeed, of this difference of refraction that the white light is decomposed in the prism; but how is it that rays of a certain refrangibility are deficient, while those whose refrangibility differs but by an infinitely small amount, more or less, manifest themselves? The light which we call white—would thus seem, if we might so speak, not to be *complete* light? Has it not lost something in coming from its focus to the eye, either in the sun itself, or in the terrestrial atmosphere? It is certain that the light loses some of its rays in traversing the ærial envelope of our planet. Sir David Brewster first brought this to notice; he showed that new black lines appear in the solar spectrum when the sun approaches the horizon, because the luminous rays pass through a greater space in the atmosphere before reaching us. These dark lines, however, which are due to the movement of the sun, are to be carefully distinguished from the invariable, normal lines which always show themselves, whatever may be the altitude of the sun in the sky. If the first are to be explained by atmospheric absorption, the second can only be owing to an absorption which takes place at the sun itself.

The explanation of the dark lines bv an absorption of rays in the solar atmosphere was proposed in 1847 by M. A. Mathiessen in a communication made to the Academy of Sciences of Paris. MM. Brewster and Gladstone both adopted it; the former suggesting at the same time a means of verifying this hypothesis. According to the English physicist, if the lines are due to the absorbing power of the solar atmosphere, which would arrest certain luminous rays in preference to others, the spectrum ought to be more furrowed with the dark lines in proportion as the rays which produce it issue from points nearer the edge of the solar disc; admitting that the rays from the edge traverse the solar atmosphere through a greater space than those which emanate from the centre. M. Kirchoff points out, with good reason, that this inference would be unavoidable if the atmosphere of the sun were inconsiderable in comparison with the diameter of that body; but everything leads to the belief that the sun's atmosphere has, on the contrary, an immense extent, and in that case two rays, issuing one from the edge, the other from the centre of the luminous disc, would traverse spaces nearly equal before reaching our eye. We should not, therefore, expect to observe any great difference between the spectrum obtained by means of one or the other of these rays. The idea thus thrown out by M. Brewster has never been experimentally verified.

The phenomenon of the lines remained therefore unexplained; nor would the mysterious reasons, doubtless, have ever been penetrated, had not physicists thought of tudying other spectrums than that of

the solar light. Any flame may serve for this purpose. The spectrum of all sorts of artificial flames have been examined, as well as that of the electric spark, of the luminous arch produced by a current between two points of charcoal, even that of the more brilliant of the stars. Observers have it in their power to vary indefinitely the nature of artificial flames; nothing is easier than to place different substances in suspension in a flame, either directly by immersing them at the end of a wire of platina, or mixing them beforehand with the liquid which supports the combustion. The study of artificial flames has revealed a phenomenon at least as extraordinary as that of the dark lines of the spectrum. When certain substances are in a state of ignition in the flame, the spectrum is traversed by colored bands of a greater brightness which are vividly depicted on the general ground of the usual colors. This circumstance had not escaped Frauenhofer, who had seen with astonishment bright lines traced in the spectrum produced by the flame of a wax candle. Different physicists, Brewster, Miller, Schwann, submitted to analysis flames obtained by burning alcohol which contained various salts in solution, and they were thus enabled to observe the bright stripes of artificial spectrums with great distinctness. Thus it was ascertained that every flame containing sodium furnishes a spectrum in which a yellow line of an extraordinary brightness is delineated. Schwann even observed that it was sufficient to mix a very small quantity of sea salt, or chloride of sodium, with the combustible liquid, in order that the spectrum should disclose its presence by the appearance of the yellow line.

In this discovery there was the germ of a new method of chemical analysis. Each metal in effect has bright lines of special colors, which correspond with it, and which retain an invariable position in the spectrum. A chemist may learn to distinguish these lines as readily as he recognizes the precipitates obtained in the laboratory by the ordinary reagents; but with the advantage that the light furnishes a reaction far more delicate and perfect than any with which chemistry was before acquainted. Arago, who accomplished so much in behalf of optics, predicted that chemistry would some day derive unexpected services from the progress of that science. A ray of light proceeding from a flame discovers by its physical properties the intimate nature of the focus from which it emanates. I shall cite an example, borrowed from M. Kirchoff, well calculated to excite surprise: "The following experiment," writes the learned physicist, "proves that thus far chemistry has no reagents which can be placed even in remote comparison with that of the spectrum as regards its sensibility. We have caused three milligrams of chlorate of soda to detonate in a part of the hall as far removed as possible from the apparatus, while we observed the spectrum of the flame of a gas-lamp giving but slight illumination; the apartment in which the experiment was made measures about sixty cubic metres. After some minutes the flame, reflected in a tawny yellow hue, presented with great intensity the characteristic line of sodium, and this line was not completely effaced till after the lapse of ten minutes. From the capacity of the hall and the weight of the salt employed in the experi-

ment, we easily deduce that the air of the apartment held in suspension but one twenty-millionth of its weight of sodium. Admitting that a second suffices for conveniently observing the reaction, and that during this time the flame uses fifty cubic centimetres or 0.0647 grams of air, containing only the twenty-millionth of a milligram of salt of soda, we may calculate that the eye very distinctly perceives the presence of less than the three-millionth of a milligram of salt of soda. In view of such a sensibility as this, we recognize that it must be seldom, indeed, that atmospheric air, at a high temperature, does not present the reaction of sodium. The surface of the earth is more than two-thirds covered with a solution of chloride of sodium, which, by the agitation of the waves, continually produces spray; the minute drops of water thus diffused in the atmosphere abandon in evaporating a highly attenuated dust of chloride of sodium, which constitutes an atmospheric element, variable as regards the proportion, but rarely, it would seem, deficient in the air."

Nothing is easier than to produce this apparition of the yellow line of sodium in the spectrum obtained by the comparatively obscure flame of an ordinary gas-lamp. While my eye was applied to the glass with which I was observing the faint spectrum of such a lamp, M. Grandeau, the chemist, who kindly repeated for me at the laboratory of the normal school the experiments of MM. Bunsen and Kirchoff, struck several times with his hand on the sleeve of his coat, and I saw the yellow line of the sodium display itself in a momentary flash on the dim field of the eye-glass. The stroke of a hand on a garment had sufficed to throw into the illuminating gas some of the molecules of sodium mixed with the dust, and these scanty molecules had instantly exerted their almost magic influence on the properties of the light. M. Grandeau, at the time when he initiated me in the experiments of the two German savants who had themselves given, at Heidelberg, an account of their extraordinary researches, was engaged in analyzing the mineral water of Bourbonne-les-Bains, and had just detected therein the two new metals which MM. Bunsen and Kirchoff had discovered in the water of Dürckheim. He took some drops of the water of Bourbonne, introduced them into the flame, where they were at once converted into vapor, and I had quite enough time to distinguish on the field of the spectrum the lines which characterize the new metals, *rubidium* and *cæsium*, the red line of the first and the blue of the second.

It was, in fact, solely through the inspection of different spectrums, which they obtained by introducing divers substances into a flame, that MM. Bunsen and Kirchoff were led to the discovery of these two new simple bodies. Familiar with the bright lines characteristic of all the known metals, they were warranted in attributing to new metals the bright lines which corresponded neither with iron, nor sodium, nor lithium, nor potassium, &c. Guided by this induction, they were enabled to seek directly for these metals in substances which called forth in the spectrum the appearance of the new lines. Hence it was that they extracted *cæsium* from the mineral water of Dürckheim, and *rubidium* from a mineral of Roxena, in Moravia, called by mineralo-

gists *lepidolite.* These two metals are highly alkaline, and take their place in the chemical series by the side of potassium and sodium, of which they partake the principal properties.

The optical analysis, by reason of its extreme delicacy, furnishes the means of recognizing the slighest traces of the metals which possess the property of communicating a vivid coloring to certain zones of the spectrum. To give a striking instance: when the ashes of a cigar, a little moistened with chlorhydric acid, are introduced into the flame which furnishes the spectrum, we see appear the yellow line of sodium, the pale red line of potassium, the intensely red line of lithium, a very deep orange line and a green one, both corresponding with calcium; thus in an instant we have verified the presence of five metals. By the same means we discover in mineral waters, especially when the experiment is made with mother-waters, (eaux-mères,) the least traces of the numerous metals which communicate to them these peculiar medicinal properties. The metals are not in general characterized by a single band; that is the case only with sodium, whose yellow band is distinguished by very vivid outlines and a peculiar brilliancy. It is true that we can scarcely introduce any substance whatever into the flame without the appearance of this line, even when that substance does not contain sodium; it is sufficient that such body should have been subjected for some time to the action of the air in order that it should give the reaction of sodium when presented to the flame. We have seen that the dust detached from clothes at some distance from the apparatus suffices to produce this effect. The wire of platina, with which many substances are suspended in the flame, also reveals the presence of sodium when the wire has remained some time exposed to the air.

After the reaction of sodium, the most sensible and distinct is that of lithium; this metal gives rise to two lines well defined, the one a very pale yellow, the other red and brilliant. This reaction is of a delicacy almost as great as even that of sodium. MM. Bunsen and Kirchoff have seen the red ray appear after the detonation, at some distance from the apparatus, of nine milligrams of carbonate of lithium. They compute that their eye has thus been able to detect the presence of nine-millionths of the carbonate of lithium in the air. They have discovered lithium in a multitude of substances where its presence was not suspected, in sea-water, in the fucus drifted by the Gulf Stream on the coasts of Scotland, in the granites, in mineral springs, in the ashes of wood growing on granitic formations, in the ashes of tobacco and of the leaves and cuttings of the vine, in those of cereals grown on a granitic formation, &c. Potassium is recognized by two lines, one situated in the red, the other in the violet, at the two extremities of the spectrum, and by a third intermediate line much more faint. The remoteness of the two principal lines, placed at the two ends of the visible spectrum, render this reaction but little sensible; the eye can only distinguish about one-millionth of a milligram of chlorate of potash in a flame.

The alkaline metals have more simple spectrums than the metals which enter into the composition of the alkaline earths. Strontium

gives eight remarkable lines, six red, one orange, and one blue, and the eye is able, by means of the spectrum, to perceive even six-millionths of a milligram of this metal in the air. Calcium, a metal which combines with oxygen to form lime, gives three lines, green, red, and blue, which appear only in intense flames. Barium, the metal of baryta, is distinguished by two green lines. Iron, which produces very numerous lines, manganese, zinc, copper, gold, all the metals, in a word, have been tried by MM. Bunsen and Kirchoff, and they have carefully studied the lines which each of them exhibits in the spectrum. These bright zones remain invariable, whatever may be the composition of the salt, in which the metal is contained; they are still the same when the metal is directly volatilized in the flame or in passing a strong electric current between two metallic points placed at some distance from one another. The optical properties which we have thus indicated are, therefore, attributes of the simple bodies themselves, and they may be observed at all times when these latter are raised to a high temperature.

This curious investigation of the bright lines of the artificial spectrum has an intimate and close connexion with the explanation of the dark lines of the solar spectrum. This connexion, however, it is not easy to discover at the first glance, and it even escaped so ingenious a physicist as M. Foucault. In 1849 M. Foucault announced that he had observed the following fact: when we are examining in a spectrum the yellow line of sodium, from being bright it becomes dark if we vividly illuminate the source of artificial light in which the sodium is in suspension. M. Foucault was observing the voltaic arch which unites two points of carbon, and he saw a bright yellow line produced on the spectrum, due to the presence of a compound of sodium reduced to incandescent vapor by the action of the current. Now, when the luminous voltaic arch was traversed by the rays of the solar light that line became dark.

This strange phenomenon was neither explained nor generalized by the French physicist. M. Kirchoff was ignorant of it when, in 1859, he commenced with M. Bunsen his series of fruitful experiments. He showed that the bright line of sodium occupies in the series of elementary colors the place which, in the common solar spectrum, is occupied by the black line which Frauenhofer designated as the line D. To borrow his own expressions, the line D is only the bright line of sodium *reversed*, (it would surely be better to say extinguished.) But how is this line to be extinguished in a flame which holds sodium in suspension? We have seen that it is by directing upon this flame the rays of a flame still more vivid. If we observe the spectrum of the sodium flame, we shall perceive at first the characteristic yellow line; let us then allow the solar light to penetrate with increasing intensity into this flame, and the yellow line will grow pale by degrees, and at length will become dark when the spectrum produced by the sun shall have overpowered that of the artificial flame. What occurs with sodium occurs with all the metals. M. Kirchoff has converted the red line of lithium into the dark line just as he had done the yellow line of sodium; the other metals likewise present, though with

less distinctness, the phenomenon of reversal. What is proved by these phenomena? It is, that of all the rays of natural light which traverse the artificial flame there are absorbed in greater abundance, the rays which this flame would emit were it alone shining; or, to speak more scientifically, the flame has an absorptive power correspondent to its emissive power.

Let us now represent to ourselves the sun consisting of a nucleus, the focus of an incessant and intense light, and surrounded by an atmosphere. This envelope, which is of a temperature less elevated than the central nucleus, will absorb in preference the rays similar to those which it would give out in greatest number if, supposing the globe of the sun removed, the atmosphere remained as sole focus of light and of heat. Here the solar atmosphere fulfils the part which the pale artificial flame did in the experiments of M. Bunsen, and the solar globe that of the more vivid flame which *reverses* the bright lines of the artificial flame. The solar atmosphere, isolated from that which it envelopes, would furnish a spectrum, crossed with bright lines, corresponding to all the substances which it might contain in ignition. The intense light of the nucleus of the sun extinguishes all these lines, and, in place of this imaginary spectrum of dark ground covered with colored lines, it gives a spectrum of a bright ground covered with dark lines. The spectrum of the sun is in some sort the negative proof of the spectrum of its atmosphere; we find a dark line in the place which corresponds to the bright line of sodium. We may affirm, then, that this bright line would be found in the spectrum of the solar atmosphere; or, in other terms, that sodium in ignition is present in that envelope.

The sun reverses all the bright lines which its own envelope would furnish; or, in other words, each of the dark lines of the spectrum reveals *negatively* the presence of a particular simple body in the atmosphere of the central star. Now we count, in fact, thousands of dark lines in the spectrum. How rich, then, in simple bodies must be the orb which dispenses to us light and heat! Many of these lines occupy the places which correspond to known terrestrial metals; we may say, without hesitation, that the line D pertains to sodium, another to lithium; here we see sixty black lines all coinciding with the bright ones of iron, there the lines of calcium, of magnesium, of sodium, metals so widely diffused over the surface of the earth; we retrace the brilliant groups of chrome as black lines in the solar spectrum. It was highly interesting to search there for nickel and cobalt, which are almost constant accompaniments of iron in meteorites. These two metals produce a very considerable number of colored lines, less bright than those of iron. All the most vivid lines of nickel are found reversed; that is, black, in the spectrum of the solar light. We distinguish also a few of the lines of cobalt; but, strange to say, not the brightest of those lines. Barium, copper, and zinc appear to exist in small quantity in the solar atmosphere; on the other hand, there has no distinct trace been discovered of gold, silver, mercury, aluminium, silicium, which is so abundant among telluric metals, cadmium, tin, lead, antimony, arsenic, strontian, and lithium.

The discoveries of MM. Bunsen and Kirchoff no longer permit us

to doubt that the sun has an atmosphere of a temperature lower than that of the luminous nucleus, properly so called, and which holds in suspension the greater part of the simple bodies which we find on our planet. This grand conception accords well with the hypothesis of Laplace, who attributed the formation of all our planetary system to the gradual cooling of a single nebula, in which the cosmic matter at present condensed in the sun, the planets and the satellites, was primitively diffused through the entire space which that system occupies. The smallest bodies naturally cool most rapidly; the moon appears frozen, without atmosphere, without water, without organic life; there is something mournful and appalling in its aspect under the telescope. The earth has cooled less promptly than its satellite, but far more rapidly than the sun, whose fervid atmosphere still contains the numerous substances which on our planet have been long since condensed and fixed in the solid rocks. Our impoverished atmosphere contains nothing but the elements necessary for the support of organic life, oxygen, azote, carbon, and water, and our understanding can with difficulty accustom itself to the idea of an atmosphere charged with iron, with alkaline metals, with bodies the most different in a state of combustion. It would require the pen of Dante to portray that chaotic condition of nature, that rain of metallic fire, those luminous clouds darkened by the contrast of a still intenser light, that incandescent ocean of the sun, with its tempests, its currents, its rushing and gigantic water-spouts; such pictures set at defiance even imaginations the most enamored of the fantastic and the strange, and our dreams evaporate as a drop of water before that blazing lava, that focus, that refulgence of the world, source of all warmth, of all movement, of all life.

On such a subject nothing can be more eloquent than the precise language of science; it derives its force from its very humility. If metallic vapors surround the sun in the form of an atmosphere, we comprehend that they may be condensed in clouds, like the vapor of water in our own atmosphere. Galileo regarded the spots of the sun as clouds floating before the lustrous body from which the light radiates; but this hypothesis has been generally abandoned by astronomers. In order to understand the theories which are at present adopted respecting the physical constitution of the sun, let us describe the appearance which it presents when examined under a high magnifying power.

The entire surface appears covered with innumerable small inequalities, similar to marbling, or rather to the rugosities of an orange. On the luminous ground are seen dark spots of a brownish grey or black color, and of very irregular forms. When these spots are observed for several days in succession we perceive that they make their appearance on the eastern border of the disc, advance towards the centre, pass it, and disappear behind the western border. Sometimes the same spots are seen to reappear after having made an entire circuit. It is this phenomenon, indeed, which has afforded the means of estimating the velocity of rotation of the sun. The spots of the sun have very distinct outlines; they usually exhibit

a black portion, nearly central, surrounded by a penumbra not so deeply shaded and sharply defined as regards the darkest zone. The penumbra is generally a little lighter around the central black spot. It is quite rare to witness a spot without penumbra or a penumbra without a spot.

When we observe a spot during several days, very curious changes are remarked in the outlines of the black portion and the penumbra. If the spots were adherent to the body of the sun itself and, as La Hire and Maupertuis still believed at the close of the last century, were species of isles or scums in the solar ocean, we should naturally see first one part of the penumbra vanish, then the black central nucleus, then the other side of the penumbra. It is observed, on the contrary, that as the spot advances towards the western border of the solar disc, the western penumbra, instead of diminishing, increases in size, the eastern penumbra shrinks and is effaced; lastly, the black central nucleus itself disappears before the western penumbra. In reference to this observation, which is due to Wilson, and to give an explanation of it, William Herschel, in 1779, surmised that the sun has an envelope of a nature altogether peculiar. In the centre he supposed there might be a solid and opaque nucleus, surrounded on all sides by a gaseous and transparent atmosphere, as in the case of the terrestrial atmosphere; this might be composed of two strata: an exterior luminous one, the true photosphere of the sun; and a lower stratum, obscure or feebly illuminated by reflection. How, by this hypothesis, are we to explain the phases of the solar spots? Imagine that a hurricane, rends the atmosphere over an immense expanse, (there are spots whose extent is not less than the whole surface of the earth;) at the bottom of the gulf thus formed, the terrestrial observer will perceive the solid nucleus of the sun as a dark spot, and the first atmosphere, slightly transparent and faintly illuminated, as a penumbra encircling the central spot. It will thus be easily comprehended that the movement of rotation of the sun will, by presenting the object obliquely, withdraw from our view one of the sides and the bottom of this vast chasm before withdrawing the opposite side. All the phenomena described by Wilson are thus very easily accounted for. But by the influence of what forces is it that the luminous veil of the sun and the second semi-diaphanous veil are torn apart to show us the opaque nucleus? This no one has been able to explain. Herschel supposed that the solid nucleus was covered with volcanoes, whose vapors, discharged with great force, might break up through the solar atmosphere; but this is a supposition wholly gratuitous, which nothing has seemed to confirm.*

A discovery made by Arago, in 1811, seemed to give a new degree of probability to the strange hypothesis of Herschel on the constitution of the sun. It had been long believed that the light emitted by incandescent bodies was not polarized; Arago observed, on the contrary, that the light proceeding from an incandescent body, solid

* Phenomena lately observed indicate that the nucleus of the sun, as well as its atmosphere, is subjected to violent commotions. J. H.

or liquid, always presents traces of polarization. The flame of a gas in combustion alone presents the properties of normal light. This observation furnished a very simple means of discovering the physical constitution of the sun. If it were composed of an incandescent liquid mass it ought to transmit polarized light. If the photosphere were gaseous, the contrary ought to take place. Now, in regarding the sun with a polariscope, Arago found no indication of polarization; thence he concluded that the luminous part of the sun is gaseous, and not liquid or solid.

The two atmospheric envelopes, which, as Herschel and Arago agree in admitting, exist around an opaque central sun, possess a probable thickness of about 4,000 kilometres; but the singular phenomena observed during the total eclipse of the sun of the 8th of July, 1842, obliged astronomers to recognize the existence of still a third solar atmosphere above the photosphere properly so called. These phenomena were perceived anew during the eclipse of the year 1860. At the moment when the moon has entirely covered the luminous solar disc, the lunar screen is surrounded by a brilliant luminous aureola, to which has been given the name of *corona;* from the border of the moon are projected elevations or protuberances, which observers compare sometimes to serrated rose-colored mountains, sometimes to masses of ice tinted red, sometimes to immovable red flames. These protuberances are of a height which may reach to 80,000 kilometers, a distance which surpasses even the diameter of the sun. The old theory of Herschel can render no account of these strange appearances. If the sun had the photosphere for its exterior envelope, the sky ought to be completely obscure at the moment when the lunar disc entirely covers the luminous body. We have been compelled, therefore, to admit that there exists a third atmosphere, of considerable transparency and vast extent, which encompasses the photosphere itself.

It was impossible that M. Kirchoff, in the sequel of the admirable discoveries which he had made with M. Bunsen, should not think of reforming the astronomical doctrines relating to the central star of our planetary system. He has arrived at the conclusion that the visible disc of the sun is not formed by a photosphere; he does not believe in the two envelopes of Herschel and in the opaque central nucleus; he regards the sun as an incandescent body of which the outlines are those of the luminous globe itself, which our eye perceives, and which is surrounded by an immense atmosphere rich in substances of the greatest diversity. The old theory was entirely founded on the appearances of the spots. M. Kirchoff considers them as clouds floating in the solar atmosphere; he admits that these clouds may be formed at different heights, as occurs in our own atmosphere. Two superposed clouds, of unequal extent, appear to us far off as a dark spot encompassed by a penumbra. It cannot be denied that in placing at the centre of the sun an opaque nucleus, and in giving it, for a first atmosphere, a zone half obscure, we present to the understanding an hypothesis which strongly contravenes the instinctive inductions of good sense. If the photosphere is the focus of solar heat and light,

it is hard to comprehend why all the substances it contains have not been gradually raised, however feeble the conductibility, to the temperature of incandescence. One may keep for a time a piece of ice in a warm chamber, but it always ends by melting. Suppose the nucleus of the sun as cold as you please, sufficiently cold to be inhabitable by beings like ourselves, the radiation of that furnace which we call the photosphere must gradually elevate the temperature of the first atmosphere and that of the solid globe itself. I think, therefore, that M. Kirchoff has reason to reject a theory which is opposed to all the known laws of the diffusion of heat.

There still remains, however, the celebrated observation of Arago. If, as M. Kirchoff contends, the luminous disc is not a gaseous photosphere, how is it that it transmits to us unpolarized light? On this point, the German savant remarks that if liquid luminous bodies emit polarized light, it is because we observe them when at rest; if we examined them when agitated, he thinks that the light being then emitted under the most different angles there would be no uniformity in the direction of the vibratory movements, consequently no polarization. He conceives, therefore, that the visible surface of the sun may very well be liquid and yet emit unpolarized or natural light, because that vast ocean of fire has not a smooth surface like a mirror, but is unceasingly furrowed by enormous waves and swept by tremendous tempests. To form such suppositions is not to yield to the sway of the imagination. All movement of air or water results from a simple difference of temperature: some degrees less from the pole to the equator on our earth, and we see the ocean traversed by currents and counter-currents, the atmosphere open to the winds, agitated by tempests; but the fluctuations of temperature, so comparatively slight on our planet, must, if we reflect, be immense in the sun and around the sun. The condensation of the metallic vapors of the atmosphere, the vaporization from the solar ocean, are phenomena far otherwise stupendous than our terrestrial thunder-storms. What force must the winds have on a sphere so vast as that of the sun! What fearful deluges must pour from the bosom of clouds as extensive as our widest continents and charged with metals in ignition! The variations of temperature in the solar atmosphere may be estimated, with great chances of probability, at many hundreds of degrees; the atmospheric pressure must vary in the same proportions, while it is by millimetres only that, in terrestrial barometers, we compute the variations of pressure in the mercurial column which forms the equilibrium to the weight of the atmosphere. And yet, we know a rapid fall of some millimetres in the barometric column is the certain forerunner of a violent tempest.

After having described the sun as an incandescent liquid globe, encompassed with a dense atmosphere pervaded by simple bodies, which we find in our own planet, M. Kirchoff stops. He seeks not to explain how this focus of heat has been kindled, nor how it is maintained. This question, if it cannot be completely resolved, deserves, at least, to be discussed. If the sun were only a heated body radiating in space, like a red-hot cannon ball, we must conclude that

it could not long remain so bright as it appears to us and as it appeared to our most remote ancestors. The heat which it loses by radiation is truly enormous. M. Pouillet has calculated that during each second it gives out 13,300 calories, that is to say, 13,300 times the quantity of heat necessary to raise one gram of water from zero to 75 degrees C. Would we have an idea more easily appreciable of that quantity of heat? Employed to exert a mechanical effect, it would be sufficient to raise a weight of 5,600,000 kilograms to an altitude of one metre.

This expenditure of heat is so enormous that the surface of the sun would, without doubt, soon become obscure if the process went on without variation, and nothing returned to the sun the heat which it is constantly losing. Now, whence is derived this heat thus continually renewed? Can we imagine that it results from a chemical combination, from the combustion of different substances? If the sun were a mass of incandescent charcoal, it has been computed that 1,200 kilograms of that body would be consumed every hour for each square metre. If the central orb was of the same composition as our gunpowder, during each minute a layer of powder one metre in thickness would be burnt, and our present sun would disappear in nine thousand years. On the same hypothesis the solar diameter would eight thousand years ago have been double what it is to-day. I present these singular suppositions only to make it apparent that the phenomenon of the solar heat perpetually maintained cannot be compared with the phenomena of combustion, with which our experience is most familiar. We must prepare our minds for something extraordinary when the question relates to that immense focus whose activity seems never to slacken. Everything leads us to believe that the sun does not consume itself alone, but that it receives incessantly from without, new materials, which are precipitated into its orbit and there become incandescent. Let us suppose that the sun is encompassed by an immense cosmic ring formed of a multitude of meteorites. Attracted by the powerful mass of the sun, these meteors will describe spirals more and more closely approaching the centre with a velocity always increasing. Arrived in the solar atmosphere, they will fall upon the sun with the prodigious velocity which gravitation will communicate to them, a gravitation which at the surface of the sun is twenty-eight times greater than at the surface of the earth. The swiftness of a meteor arriving at the sun exceeds 600 kilometres a second; supposing that it has entered the solar atmosphere with the frozen temperature of the interplanetary spaces, we see that it must there promptly be raised to temperatures higher than we can imagine. M. Thomson, a learned Englishman, at once a mathematician and physicist, has calculated that to maintain the actual solar heat it would suffice that there should fall every year into the solar focus a quantity of meteoric matter which would cover the surface of the sun to the thickness of nine metres. Suppose, if you will, that twice as much is necessary, that every year the level of the solar seas is raised eighteen metres by virtue of this continual rain of incandescent meteors, it would require four thousand years in order that the apparent diameter

of the sun should be increased by one second—forty thousand years that it should be enlarged by one minute. At this rate, at the end of two thousand years a terrestrial observer who should have lived all that time would not see the sun differ more from itself than we see it differ every year from season to season, in proportion as the earth approaches or recedes from it. If the mass of the sun were augmented by the addition of meteoric substances, we should not be in a position to perceive it, while, in return, the constancy of the sun's diameter affords no argument for rejecting this hypothesis, which has the advantage of assigning a rational cause for the development of the solar heat.

It will be asked, perhaps, whence come those meteors whose fiery torrent falls incessantly on the surface of the orb which lights us. Have you never seen, on a clear evening of March or September, at the time of the equinoxes, a whitish gleam in the western part of the heavens? It occupies from twenty to thirty degrees in extent and projects itself above the horizon, following nearly the direction of the ecliptic. This has been called the zodiacal light, because those who first observed it conceived it to be limited to the zodiac. Under the hazy sky of our climates this pale glimmering is perceived but rarely after the evening twilight or before the rising of the sun at the beginning of spring or autumn, and it is easily confounded with the gleams of the receding or approaching day; but under the tropics the phenomenon displays itself in all its magnificence. On the summits of the Cordilleras, in the prairies of Mexico, under the transparent skies of Cumana, upon the coasts of the Sea of the South, the zodiacal light appeared to Alexander von Humboldt more lustrous than the milky way. At the equinox, at the moment when the solar disc sinks beneath the horizon, total obscurity succeeds almost immediately to day; and at once the zodiacal light is seen stretching up to half the height of the heavens and only vanishing at the approach of midnight.

Domenico Cassini, in 1683, was the first who observed the zodiacal light, and he considered it as a sort of luminous ring connected with the solar equator; he recognized in effect that this light follows the solar equator in proportion as the latter withdraws itself from the ecliptic. Thomson thinks that this vast luminous ring is the reservoir of the meteors by which the central sun is maintained. Such a theory adapts itself readily to the great cosmogenic conception of Laplace: The zodiacal ring extended between the sun and the orbit of the earth would, under that view, be a residue of the cosmic matter which, in the beginning, composed the entire nebula from whence emerged by degrees our complex system of planets.

However this may be, in proportion as astronomy studies with more care the phenomena of the heavens, does it meet there with more surprising marvels. What admirable discoveries have been recently made in our own solar system which had been supposed to be entirely explored! Among these discoveries, that of MM. Kirchoff and Bunsen must be regarded as one of the most important. The spectral analysis of the solar atmosphere has furnished the proof of the chemi-

cal unity of our planetary system, and perhaps it will some day reveal, when applied to the brighter stars, a physical relationship between our own system and all those which fill the immeasurable depths of space; but if it opens to us in some degree the portals of the infinitely vast, it reconducts us by another route to the idea of unity in nature. In studying the spectrum we at present recognize each simple body held in suspension in the flame whose rays are decomposed by the glass-prism; but what is a simple body which betrays its presence, not by one bright stripe alone, but by two, three, sometimes by sixty stripes? In proportion as the spectrum increases in distinctness, the number of luminous stripes increases for each substance; shall we ever see them all? It may well be doubted. Here, then, there is a multiplicity and indeterminateness which accord but ill, it must be confessed, with the theoretic idea which we entertain of a *simple* body, a substance not compounded, always identical with itself, the *substratum* of all chemical combinations. Must we admit, with some resolute spirits, that the bodies which we call simple, appear so to us only because thus far we have not succeeded in decomposing them? Should we conclude that the different simple bodies, if there are really such, are but formed of one and the same matter in different states of condensation? We thus find ourselves attracted towards the idea of unity of substance. Gas, liquids, solids, vacuum and plenum, bodies and celestial spaces, satellites, planets, suns, &c., would be but transitory forms of something eternal, the ephemeral images of something which cannot change; in the vortex of phenomena, in the eternal movement of allsubstance, the cosmic history everywhere shows us the future in the present and the present in the future.*

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* All the facts in regard to solar chemistry can be briefly stated as follows:

1. Solid and liquid bodies when highly heated give a continuous spectrum without lines.
2. Flame in which solid or liquid substances are volatilized give a spectrum crossed with bright lines.
3. Each substance in the flame gives a line or a series of lines peculiar to itself, so that the presence of any substance in a flame may be known by inspecting the spectrum of the flame. Hence the value of the spectrum in chemical analysis.
4. When a bright beam of light from a solid or liquid behind a flame that is producing bright lines is sent through this flame, the bright lines disappear and dark lines take their place. These dark lines are called the reverse or negative lines of the substance in the flame.
5. The spectrum from the sun is crossed with a large number of dark lines, many of which are found to exactly coincide in position and magnitude with the negative lines produced by various metals found on the earth.
6. The complex system of negative lines of iron, for example, is found in the spectrum of the sun, and hence it is inferred from strict analogy that this and other metals exist in a volatile state in the atmosphere of the sun.
7. The constitution of the sun to produce this result must be that of a solid or liquid nucleus emitting light of great intensity, and surrounded by an atmosphere also emitting light, but of less intensity.
8. The dark lines of the spectrums of the planets are the same as those of the sun. This is what might be expected, since they shine by reflected sun light; but the lines of the fixed stars, of Sirius, for example, are different from those of the sun.
9. The inferences drawn from the facts above stated have not been fully accepted as yet by scientists of celebrity. Since the lines in the spectrum of the sun are very numerous, there is a possibility that those which are found to indicate iron, for example, may be an accidental agreement. But Kirchoff has calculated the chances of an accidental agreement, and finds it to be one divided by one million of millions of millions.

SECRETARY, *S. I.*

PROGRESS OF ASTRONOMICAL PHOTOGRAPHY.

FROM THE MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY, FEBRUARY 14, 1862. No. 4.

ADDRESS DELIVERED BY THE PRESIDENT, DR. LEE, ON PRESENTING THE GOLD MEDAL OF THE SOCIETY TO MR. WARREN DE LA RUE.

Gentlemen: In the report which has been read to you, you have been informed that the council have assigned the gold medal of the society to our worthy secretary, Mr. Warren De La Rue; and, as it is the custom, it becomes now my duty to explain to you, in a few words, the grounds of their decision.

You know that for many years Mr. De La Rue has devoted the energies of his mind, a large expenditure, and such leisure as he could abstract from the complicated cares of an extensive and well-known commercial concern, to the earnest cultivation and systematic pursuit of practical astronomy, and that he has been one of the most frequent contributors to our evening meetings, upon a variety of subjects—all requiring much knowledge, skill, and labor in their treatment.

Discoveries in the regions of science so crowd upon us in our own times, that valuable inventions and striking results soon fade from the memory, and are lost in the brilliancy of those which rapidly succeed them.

I must therefore request your indulgence whilst I lay before you what it is that Mr. De La Rue has done to entitle him to receive, and which justifies the council in awarding him the highest honor that it is in the power of the Royal Astronomical Society to bestow.

Mr. De La Rue has not only conducted the usual observations which are made at most private observatories, but he has directed the resources of a rare mechanical genius to improvements in the most approved methods of polishing the specula of reflecting telescopes, and perfecting the mechanical arrangements by which operations of such refined nicety are performed.

On this subject there can be no higher authority than Sir John Herschel, who, in an article on the *telescope*, published in the *Encyclopædia Britannica*, says:

"Such is Mr. De La Rue's mechanism, which has afforded very admirable results in the production of specula 13 inches in aperture and 10 feet focal length, the perfection of which is enhanced by his practice of bestowing the same care and precision on every step of figuring of the speculum, from the grinding, the smoothing on a bed of hones, or rather a slab of slate cut into squares, carefully brought to the same figure, and to the figuring of the polisher itself, which being thus previously rendered almost perfect, the speculum is saved

the rough work of having to figure the polisher for itself on every occasion of repolishing."

In a more private communication to myself on the same subject, Sir John adds that "Mr. De La Rue's machinery, though grounded on Mr. Lassell's rotary principle, is by no means a servile imitation of Mr. Lassell, inasmuch as several distinct improvements have been introduced tending to distribute the polishing action more equally over the whole surface of the metal. One of these improvements consists in his interposition of a plate between the supporting plate and sliding plate of Mr. Lassell's traversing slide, which, being made to revolve, causes the traversing movement of the speculum to take place, not across the same diameter of its area, but at every stroke across a different diameter; and he also obviates the irregularity of the motion of Mr. Lassell's polisher on its centre, by governing that rotation by mechanism, instead of leaving it to be determined by the excess of external over internal friction."

But it is in celestial photography that Mr. De La Rue has made his most important discoveries, and displayed an unfailing fertility of mechanical invention. Wisely acknowledging the growing vastness of the several departments of the same science, he has latterly, in a great measure, restricted his researches to the delineation of the various aspects of the heavenly bodies, through the medium of photography.

It is only by acknowledging and adopting the principle of the division of labor that great results can be obtained, either in the pursuits of commercial industry or abstract science.

The days of the admirable Crichton have long since passed away.

Indeed Lord Bacon himself, in the *Novum Organum*, well observes, in anticipation of the influence of this general principle:

"Then men shall begin to find out their own powers when all will not essay to do the same things, but each man will employ himself in the work for which he is most apt." *

Mr. De La Rue's claim to the special notice of astronomers, as a delineator of celestial objects through the medium of photography, does not rest on the absolute priority of his application of a well-known art in a new direction. It is rather based on the fact that by methods and adaptations peculiarly his own, he has been the first to obtain automatic pictures of the sun and moon, sufficiently delicate in their detail to advance our knowledge regarding the physical characters of those bodies, and admitting of measurements astronomically precise.

The late Mr. Bond, of Cambridge, in the United States, in the year 1845, with the assistance of Messrs. Whipple and Bond, obtained good pictures of *α Lyræ* and of *Castor;* and that, in this year, Signor De Vico made an unsuccessful attempt to photograph the nebulæ in *Orion.*

At about the same time, or a little later, the Rev. J. B. Reade took photographs of *α Lyræ* at my observatory at Hartwell, and at his own observatory at the Vicarage of Stone.

* "Tum enim homines, vires suas nosse incipient, cum non eadem infiniti, sed alia alii præstabunt"—*Liber* 1, aphor. cxiii.

Mr. Glaisher, writing in 1851, as reporter upon philosophical instruments in the great exhibition, Class X, and upon Mr. Bond's daguerreotype of the moon, taken in 1850, and which was placed in the exhibition of 1851, says upon photography: "Let us now view photography in its application to science: a process by which transient actions are rendered permanent, and which enables *nature* to do her own work—or, in other words, which causes facts permanently to record themselves—is too well fitted for the purpose of science to be long overlooked; but the difficulties to be overcome in its application have been and still are great, and the results proportionably few in number. We consider, however, that the commencement of a systematic application of the photographic process to the purposes of astronomy is indicated by the daguerreotype of the moon by Mr. Whipple; and great, indeed, will be the benefit conferred upon astronomical science when we obtain permanent representations of the celestial bodies and their relative positions through the agency of light."

Enlarged copies of Mr. Bond's photographs were laid before the Royal Astronomical Society in May of the same year. At the meeting of the British Association of Science, held at Ipswich in July, 1851, under the presidency of the learned astronomer royal, a daguerreotype of the moon was shown to the members of the mathematical section by Mr. Bond; and his royal highness the Prince Consort, whose loss we now deeply deplore, was present on the occasion and inspected the daguerreotype.

On the subject of the connexion of photography and chemistry with astronomy some interesting remarks appear in the admirable lecture on the sun, delivered by the respected Professor Walker before the British Association of Science, under the presidency of our esteemed member Lord Wrottesley, in 1860, at Oxford.

There are several references to celestial photography in the various volumes of the *Comtes Rendus*, which can only be brought to your notice in the form of notes.*

It was the sight of these very promising daguerreotypes of Mr. Bond which, in 1851, first gave the impulse to Mr. De La Rue's labors in this direction. In 1852 he availed himself of the collodion process invented by Mr. Archer in the preceding year, and succeeded in obtaining a good picture of the moon. In 1853 Professor Phillips obtained talbotypes of the moon at York. In 1854 lunar photographs were secured at Liverpool under the supervision of our respected

*1849.—Vol. xxxviii, p. 241. "On the Observations of the Sun." By M. Faye.

1858.—Vol. xlv, p. 705 and following pages. "On the Photographs of the Eclipse of March 15, by MM. Porro and Quinet." By M. Faye.

1859.—Vol. xlviii, p. 174. "Report on a Memoir addressed by M. Liais on the occasion of the Total Eclipse of 1858, September 7."

1859.—Vol. xlix. "Second Memoir on the coming Eclipse of 18 July."

1860.—Vol. li, p. 965. "On the State of Astronomical Photography in France."

1861.—Vol. liii, p. 997. "On the Perfecting Meridional Observations of the Sun without an Observer." By M. Faye.

1862.—Vol. liv, pp. 43 to 159. "On Photographs of the Sun, taken by M. Belfort during the Eclipse of the 31st of December last."

member Mr. Hartnup. In 1855 the Rev. J. B. Reade, who has distinguished himself by his discoveries in photography, obtained special notice and honorable mention at the Paris exhibition for his photograph of the moon. Others also have been taken at Rome by Signor Padre Secchi, at Brighton by Mr. Fry, and in the vicinity of London by Mr. Huggins. All these photographs possess merits of their own, and give decided promise of future and greater success.

Admiral Smyth, in the *Speculum Hartwellianum*, pp. 249, 250, and 285, speaks of Mr. Bond's labor in celestial photography, particularly pointing out that in 1857 a photograph was sent to the astronomer royal taking in the whole field between *Mizar* and *Alcor*, with such exactitude as to show their angles of positions and distances.

Mr. De La Rue's success in obtaining photographic pictures of the moon possessing great sharpness of definition and accuracy of detail is owing to the happy combination of a variety of causes. Possessing a large mirror of such exquisite defining power that but few existing telescopes equal it in accuracy of definition, and brought into figure by *his own hands*, and by peculiar machinery of *his own contrivance*, he was at once freed from those imperfections in the actinic image which are of necessity inherent in the very best refractors, even when corrected most accurately for chromatic dispersion.

Mr. De La Rue at first had no clock-work apparatus to govern the motion of his telescope, and, after making several successful lunar photographs with the aid of the hand-gear of the telescope, he discontinued his selenographical experiments until he had removed from Canonbury to Cranford—a change of residence which, for the interests of astronomy, he had for some time previously in contemplation. He then furnished his telescope—his own in a double sense—with a clock-work apparatus, which from time to time has passed through numerous alterations, and which is still in course of improvement. The mechanical problem before him, as the fellows of this society well know, was one of extreme complexity; for not only must the motion of the clock-work be perfectly smooth and equable, but it must also be capable of acceleration and retardation, to keep pace, so to speak, with the ever-varying velocity of the moon in the heavens—a variation compounded of its diurnal motion and its ever-changing velocity in its orbit.

Lastly, by a rare and happy combination of chemical with mechanical skill, the time necessary for the exposure of the collodion film was materially shortened. The final result is this, that images of the moon have been repeatedly taken in the focus of the mirror, admitting of very considerable amplification, and exhibiting details on the moon's surface sufficiently clear to admit of delineation under a microscope provided with a camera lucida, and thereby furnishing materials for a more accurate selenography than has heretofore existed.

Neither must we altogether omit that by stereoscopically combining images of the moon, taken in different phases of her librations, more particularly enlarged copies, eight inches in diameter, Mr. De La Rue has brought to light details of dykes, and terraces, and furrows, and undulations on the lunar surface, of which no certain knowledge had

previously existed, and which I have had the exquisite pleasure of beholding in his observatory at Cranford.

> "Man looks aloft, and, with erected eyes,
> Beholds his own hereditary skies."

I must now turn to a department in celestial photography, where Mr. De La Rue stands almost alone. I speak of *heliography*. In April, 1854, Sir John Herschel, in a letter to Colonel Sabine, recommended that daily photographic records of the sun should be obtained at some observatory. Accordingly the Royal Society placed at the disposal of the Kew committee a sum of money to promote that object, and Mr. De La Rue was requested to administer the grant.

It becomes necessary to mention that Arago, in his elegant and popular work on astronomy, translated by two eminent fellows of our society, states that MM. Fizeau and Foucault, in 1845, obtained a photographic image of the sun, and two spots on its disk, delineated with much apparent sharpness and accuracy; but, however this may be,* it is certain that no uniformly successful method of taking images of the sun had been devised until Mr. De La Rue took up the problem for investigation.

Yet great as had been the difficulties in obtaining a really accurate and available picture of the moon they sink into insignificance when compared with those which had to be overcome in the photography of the sun; for to obtain any automatic pictures of the sun's photosphere available for practical purposes it was found necessary to institute a series of preliminary experiments before actual operations could be successfully commenced. At first nothing but burnt up and solarized pictures could be obtained by any method that had hitherto been devised, or with any the least sensitive of the media that could be procured. Now, with the help of the Kew photoheliograph, as devised by him, and described in vol. xv of the *Monthly Notices*, *heliography* is the easiest and simplest kind of astronomical photography. The method devised by Mr. De La Rue will enable any photographer of common average skill to take excellent heliographs. Professor Selwyn, of Cambridge, succeeds in getting good pictures of the sun with the apparatus made for him by Mr. Dalmeyer, after the pattern of the Kew photoheliograph.

Mr. De La Rue announced at the last meeting of the society that by applying the stereoscope to the examination of the sun's disk, as he had formerly done in the case of the moon, he had discovered that the faculæ on the surface of the sun are to be found in the outer or highest regions of the solar photosphere.

I ought not to conclude without alluding to Mr. De La Rue's observations on the solar eclipse of 1860; but it must not be forgotten that *one* daguerreotype picture was taken by Dr. Busch of the solar

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* Respecting this photography of the sun, the index of the *Comptes Rendus* has been searched all through, under the heads of *Arago*, *Photography*, *Soleil*, *Fizeau*, *Foucault*, *Daguerreotype*, and *Faye*, and no mention has been found whatever of the sun's picture in 1845; and there has not been found any reference to it, excepting the plate in the body of the original work itself.

eclipse in 1851, and of the solar eclipse in 1860 *four* small pictures were also taken during the totality by Professor Monserrat, under the direction of MM. Aguilar and Secchi, at Desierto de las Palmas, in Spain.

Mr. De La Rue, during the progress of the same eclipse, took many large and exquisitely defined pictures, and secured two during the totality. I have no need to enter into details, as he has already described at several meetings of this society the numerical results that follow from the discussion, and the comparisons of the photographs which he took on that occasion. A paper giving the result of his labors during the expedition to Rivabellosa has been presented to the Royal Society, and is to be considered in March of this year.

Mr. De La Rue has invented an ingenious micrometer, lately exhibited at one of our meetings, by means of which he fully confirms the hypothesis that the colored protuberances belong to the sun, and renders it almost certain that the commonly received diameters both of the sun and moon require a correction.

More recently still, photographic pictures of the sun have been obtained by Mr. De La Rue, not only exhibiting its well-known mottled appearance, but showing traces of Mr. Nasmyth's "willow leaves," and by the aid of stereoscopic pictures rendering it certain that the faculæ are elevations in the sun's photosphere.

I need not enlarge on the wonderful discoveries which have been made and the astonishing results that have been obtained by Newton and his successors in this the most fertile and exact of all the applied mathematical sciences. Neither would it become me, an humble but zealous worshipper of science, to hazard conjectures as to the *future progress of astronomy*. And yet I cannot refrain from expressing my belief that the success already achieved by our friend warrants us in entertaining the hope that before long he will be able, with the aid of stereoscopic pictures, to exhibit to us the rose-colored prominences depicted on the sensitive plates as plainly as the faculæ have already been photographed. The depths and the successive strata of those strange interlacing outliers within the solar spots may be brought into tangible view. The different planes of *Saturn's* rings* will also come into relief, the belts of *Jupiter* may be manifested as portions of his dark body, and ere long the mountains and elevated continents of *Mars* will rise up into solidity before our delighted gaze.

I may also, perhaps, be permitted to remark, that while our great national and public observatories—indeed, I ought to say those of the civilized world as well—are day by day adding to that enduring record of the transient phenomena of the heavens which will enable future

* If the subject of the present address were not now of necessity confined to improvements in celestial photography, I should here refer at some length to those exquisite and unequalled hand-drawings by Mr. De La Rue, of *Saturn*, *Jupiter*, *Mars*, and the comet of 1858, which have so often delighted and informed our society. They have embodied with micrometrical accuracy the results of years of scrupulous and skilful labor; and, as an instance of the reliable nature of the results obtained, I may mention that, by placing under the stereoscope two of Mr. De La Rue's hand-drawings of *Saturn*, taken at two distant periods, the inclinations of the planes of the rings alluded to in the text become unmistakably apparent.

ages to reach the final finish and last perfection in the calculation of the tables of the motions of the moon and the planets, to eliminate any element of error, however minute, and to detect any latent disturbing force, however feeble its effect; yet it is to *private observatories* and to observations made in the remoter regions of starry space that we are chiefly to look for new discoveries. It augurs well for the future that there is no lack in our own day of such establishments, or of accomplished observers to use them. It is almost, if not altogether, needless to bring before you the names of Admiral Smyth, or Lord Rosse, or Mr. Lassell, or Lord Wrottesley, or Mr. Dawes, or Mr. Carrington, and a host of others familiar to many of you. The elliptic motions of binary stars round their common centre of gravity, the colors of others, the discovery of new planets, the calculation of cometary orbits, the laws of change in the *variable* stars, the sudden burst upon the sight of some stars, and the gradual evanescence of others, will afford for many generations suitable and exhaustless subjects of sustained astronomical research. The instant splendor and gradual decay of certain stars is one of the most wonderful facts recorded in the history of astronomy. In 1572, Cornelius Gemma observed a star in the chair of *Cassiopeia*, transcending *Venus* herself in brightness. It was Hipparchus who first, I believe, noticed the sudden appearance of a star of singular brilliancy before unknown. By this strange discovery he was urged to construct a catalogue of stars visible to the naked eye, "that posterity might know whether time had altered the face of the heavens."

The art of photography is of the very highest importance in the promotion of exact science.

It stereotypes, so to speak, for the use of all time to come, the present aspect of the heavens.

As astronomical observations ranged in tables record the present positions of the heavenly bodies, so photography registers their present aspect. It may be that the pictures of the sun now taken will enable future ages to test the prediction of the poet,

> "The stars shall fade away, the sun himself
> Grow dim with age, and nature sink in years."

If, then, we take collective note of all Mr. De La Rue's long and varied labors since the 14th March, 1851, when he became one of our members—such as the perfecting of the figures of mirrors, the graphic observations of the planets, the incomparable photographs of the moon, the invention of the photoheliograph, the observations on the solar eclipse, the invention of the new method of obtaining numerical data, the application of the stereoscope to the examination of the surface of the *moon*, and afterwards to that of the *sun*—sure am I that the society at large will unanimously approve of the award of their medal made by the council.

It may, however, be said by some ingenious critic that photography is only an art which bears but indirectly on the promotion of astronomy, and that the reward of its successful manipulation is rather the province of those societies to confer which cultivate the art of pho-

tography, or the science of chemistry. But I cannot admit the justice of this view. What should we now say of the early fellows of the Royal Society, if they had relegated Newton, when he invented the telescope that bears his name, to the Company of Spectacle Makers for his meed of praise? What should we now think, had the barren honors which grace scientific discovery been denied to such mechanical inventors as Hadley, or Dollond, or Sir William Herschel, or Lord Rosse, or Lassell? With them the name of De La Rue, I feel, will hold no inferior place.

The President, then delivering the medal to Mr. De La Rue, addressed him in the following terms:

Mr. De La Rue: In compliance with a resolution of the council, I have the pleasing duty of placing in your hands the highest tribute to merit which they have in their power to bestow. The instruments made or improved by you, the important uses to which you have applied them, and the liberality with which you have communicated the results of your discoveries to the public, all indicate, in the opinion of the council, a mind highly cultivated, whose energy has been directed, during many years, to the attainment of scientific perfection.

But your unceasing efforts and delicate manipulation in reducing the new and wonderful art of photography to astronomical purposes, and in rendering chemistry a handmaid to astronomy, supply the more immediate motive of their approbation.

May Divine Providence continue to bestow upon you health and intelligence, and every social blessing, enabling you still further to illustrate the glory of the Creator, and to promote the rational enjoyment of our fellow-creatures.

REMARKS ON THE SMALL PLANETS

SITUATED BETWEEN

MARS AND JUPITER.

By M. G. LESPIAULT,

PROFESSOR OF THE FACULTY OF SCIENCES OF BORDEAUX.

TRANSLATED FROM THE "MEMOIRES DE LA SOCIETE DES SCIENCES PHYSIQUES ET NATURELLES DE BORDEAUX," 1861. BY C. A. ALEXANDER.

I.

In proportion as the discovery of small planets between Mars and Jupiter has been multiplied, those bodies have become, especially in Germany, the objects of a great number of highly interesting researches. The powerful magnifiers of the refractors of Dorpat and Munich have been applied to the study of their physical constitution and to the measurement of their diameters; their elliptical elements have been determined and rectified; their ephemerides calculated and occasionally even the principal perturbations of their movements. Attempts have been made to ascertain the law of the distribution of their orbits in space, from the position of the nodes and the inclination of those orbits to the ecliptic and other fixed planes, as well as from the measure and direction of their greater axes. It has been asked whether the course of these small bodies, describing curves so singularly interlaced, might not some day bring about a collision, or at any rate some approximation so considerable as to give rise to problems altogether new in celestial mechanics. The chief results of these various researches are to be found scattered through the publications of MM. Encke, d'Arrest, Littrow, Mœdler, &c., in the *Astronomische Nachrichten*, and the treatise on astronomy of Sir J. Herschel; as yet they have not been collected, and are, in general, but little known in France.* This defect I have endeavored to supply in the present notice, in which the actual state of our knowledge with regard to the small planets will be set forth, though for this purpose it has been found necessary to extend to seventy of these asteroids which we now know certain calculations which had been made only with respect to a part of them. This undertaking, in which I have been joined by M. Burat, professor at the Lyceum of Bordeaux, has led us, as will be afterwards seen, to modify or even to reject some of the conclusions at which the German geometricians had arrived.

* Professor Alexander, of Princeton, has long been occupied with the subject of the relations of the asteroids, and is now preparing an account of his results for publication in the "Smithsonian Contributions."

II.

Struck by the large interval which separates Mars from Jupiter, Kepler had been led, by theoretical considerations, to interpose between those two bodies an unknown planet: "*inter Martem et Jovem interposui planetam*, (*mysterium cosmographicum*.)" But of his own accord he afterwards renounced this hypothesis, which had been unfavorably received by learned cotemporaries. An astronomer of Florence, named Sizzi, protested, with particular earnestness, against such a doctrine. "There are," said he, "but seven openings in the head, two eyes, two ears, two nostrils, and the mouth; there are but seven metals, and but seven days in the week; there are, therefore, but seven planets." These, in the system of Ptolemy, were Saturn, Jupiter, Mars, the Sun, Venus, Mercury, and the Moon.

The idea of Kepler was revived in the second half of the 18th century. Lambert, Titius, and Bode successively called the attention of astronomers to the void which seemed to exist between Mars and Jupiter; Bode especially attached extreme importance to the celebrated law which bears his name, although, by his own acknowledgment, that law was due to Titius. In seeking a numerical relation between the distances of the planets from the sun, Titius had conceived the idea of the following series, in which each term, proceeding from the third, is double that which precedes:

$$0, \quad 3, \quad 6, \quad 12, \quad 24, \quad 48, \quad 96.$$

By adding 4 to each of these terms, we obtain a new series:

$$4, \quad 7, \quad 10, \quad 16, \quad 28, \quad 52, \quad 100.$$

In this series, 4 representing the distance of Mercury, 7 would represent the distance of Venus, 10 that of the earth, 16 that of Mars, 52 that of Jupiter, 100 the distance of Saturn; but the number 28 represented nothing and seemed properly to correspond to the distance of the Sun from an unknown planet. This hypothesis enlisted new partisans, especially in Germany, when, in 1781, the discovery of Uranus lent unexpected confirmation for the law of Bode. The Baron de Zach went so far as to publish in advance, in the *Almanach* of Berlin, the elements of the supposed planet, and he organized an association of astronomers for the search after that object. The zodiac was distributed into twenty-four zones, each of which was assigned to the special examination of one of the members of the society. The discovery was indeed not long in being made, but it proceeded from another quarter.

Piazzi, an astronomer at Palermo, had been for ten years occupied with the correction of the catalogue of Wollaston. A false indication in this catalogue called the attention of the observer to a certain region of the heavens and led him to examine minutely the most imperceptible stars. One of these, whose position had been determined the 1st of January, 1801, was found to be sensibly displaced the following day, and still more so on successive nights. Piazzi at first took it for a comet, and followed its course till the 11th of February, on which day his observations were interrupted by bad weather and

sickness. As early as the 24th of January he had sent intelligence of his discovery to Bode and Oriani; but his letters were two months in reaching them, at which time the new star was lost in the rays of the sun. Bode, therefore, could not distinguish it, but he remained convinced that this was the unknown planet, an opinion to which Piazzi subscribed and gave the name of Ceres to the object of his discovery.

A problem in astronomy, altogether new, now presented itself to geometers to determine, namely, the orbit of a planet after six weeks of observation. Many trials were made, but with results little accordant. The illustrious Gauss, then scarcely known, arrived at a solution by methods peculiar to himself, and it was by taking this calculation for the basis of his researches that Olbers found the planet anew, 1st January, 1802, a year, to a day, after its first discovery. From that time Ceres took a definite place in our system, very nearly at the distance from the sun indicated by the law of Bode, thus filling the gap which Kepler had signalized.

While constructing special charts to facilitate for the future the finding of Ceres on the celestial sphere, Olbers perceived, 28th of March, 1802, a star not in the catalogue: he followed it for several days and recognized, from its proper movement, a second planet situated at the same distance from the sun as the former, but describing a wholly different orbit. This was more than astronomers had asked for, and Pallas was received with a greater degree of reserve than Ceres. Some astronomers went so far as to deny its planetary character, an opinion to which the great eccentricity and extraordinary inclination of its orbit gave countenance by assimilating it to the comets, its resemblance to which was still more enhanced by the vaporous appearance which it assumed through the imperfect telescopes of Schrœter.

As to Olbers, he regarded the two bodies as fragments of a more considerable planet which some unknown force had shattered. On this hypothesis, it resulted from the laws of mechanics that all the projected asteroids, while describing orbits of very different eccentricity and inclinations, must continue to maintain the same mean distance from the sun, and repass, moreover, in each of their revolutions, the point in space where the catastrophe had occurred. That point was necessarily one of the nodes of the orbits of Ceres and Pallas, situated, the first in the constellation of Virgo, the second in the Whale. It was in these two regions of the heavens, according to the theory of Olbers, that the trajectories of fragments still unperceived must meet, and here, above all, that an attentive examination of telescopic stars might be expected to yield new discoveries; a conjecture which did not long remain unverified. The 2d of September, 1804, Harding perceived in the Whale a third planet, which he named Juno; and Vesta, the fourth and long the last, was discovered by Olbers himself, the 29th March, 1807, in the northern wing of Virgo. Vesta is much less remote from the Sun than the three other asteroids. The difference amounts to a fourth of its mean distance, that is, to twenty millions of leagues, a fact not calculated very strongly

to confirm the hypothesis of Olbers. In its oppositions, this planet comes sufficiently near the earth to attain the sixth degree of magnitude and be visible to the naked eye, and owes its name to the whiteness and purity of its light.

III.

Dating from the discovery of Vesta, the researches of astronomers remained long unfruitful, although their attention was constantly awake. It is true that Wartmann, at Geneva, in 1832, and Cacciatore, at Palermo, in 1835, gave notice of telescopic stars possessing a distinct and quite rapid movement of their own; but their observations, interrupted by unfavorable weather, were too incomplete and uncertain to admit of their following or again finding these assumed planets; nor was it till 1845, thirty-eight years after the discovery of Vesta, that a postmaster named Hencke, who occupied his leisure moments with astronomy, perceived the fifth of these small planets, and gave it the name of Astrea. Two years later he discoved Hebe, and, dating from this epoch, the new asteroids have succeeded one another so rapidly that their number at present is seventy [three.]

It is not without some surprise that we see discoveries of this kind, after having ceased for more than the third of a century, crowd upon us in the course of late years. This astonishing success of cotemporary astronomy may be explained, in great measure, by the increase in the number of observers, and by the construction of more extensive and exact charts than those of which our predecessors could avail themselves. The charts of Berlin, especially, which give the stars of the first ten magnitudes in the ecliptic regions, have been of the greatest service to astronomers in this kind of researches, while the more recent charts of the observatory of Paris are already becoming of signal utility. It is very rarely that the discovery of an asteroid can be regarded as the result of a lucky casualty. It is most frequently only in the course of laborious watchings devoted to this determined purpose, that a savant succeeds by means of a minute and patient comparison of the different regions of the sky with the charts which represent them, in detecting a disagreement, discovering a star not catalogued, and verifying the existence of a proper movement which shall assign a star to the class of planets. It may be added that charts of the requisite completeness are as yet provided but for a small portion of the heavens, and the explorer who would extend his search beyond this favored region must begin by constructing a special chart of the tract which he proposes to survey.

The ill success of Olbers in the ten last years of his researches is attributable to the fact that his examination was not extended to stars of less than the eighth magnitude. With not more than two or three exceptions, the planets discovered within the last fifteen years hardly transcend the ninth degree, while the greater part are of the tenth, and some even below the twelfth degree of magnitude. It is not easy therefore to estimate too highly the sagacity and admirable patience of those volunteers in astronomy who, in the strength of

their own resources, far from the great observatories, and often without the aid of the more exact class of charts, have added new worlds to our system and sometimes raised themselves, by the number and brilliancy of their discoveries, to the level of the most distinguished astronomers. Among these *laymen* of science the first rank belongs to our fellow countryman, M. Goldschmidt, who, but a few days ago, introduced to us his fourteenth planet, the seventieth of the group, and who has been, this year, the recipient of the gold medal of the Astronomical Society of London. In offering this testimonial, and in justification of its choice, the president of the society took occasion to point out the scantiness of the means at M. Goldschmidt's disposal in comparison with the grandeur of the results which he had obtained. Lutetia, for instance, the first of his acquisitions, has but the lustre of a star of the ninth or tenth magnitude, which is to say that its examination requires the closest attention on the part of astronomers who wish to observe it, even with the help of the great meridian instruments of Paris and Greenwich. And yet it was with a telescope, the aperture of which was but twenty-three lines, that our cotemporary proceeded to the discovery of this imperceptible object; a telescope supported on the bars of a chair and commanding but so limited a space of the heavens as might be seen from the windows of a garret in the Pays Latin.

The most fortunate competitors of M. Goldschmidt have been MM. Hind and Luther, who have each discovered ten planets, while M. de Gasparis has discovered eight, M. Chacornac six, M. Pogson, four, and M. Ferguson three.* To M. Hencke, as stated before, we owe two, and it is to him that the honor pertains of having first re-entered on the path of discovery which had been closed for thirty-eight years, and of having adopted, before any one else, the charts of Berlin as the basis of his researches. Within a space of some few days M. Temple associated his name with two of these minute stars, and there are seven astronomers who have severally attained a single success: MM. Graham, Searle, Laurent, Marth, Forster, Tuttle,† and Schiaparelli. Thus, by adding the four older planets, we have a total of seventy [three] asteroids actually known.

IV.

We cannot quit this subject without calling the attention of our readers to a singular circumstance connected with it, and which has been repeatedly taken notice of, especially of late, by the commission of the Academy of Sciences for prizes in astronomy. The distribution of the discoveries of small planets over the last fourteen years is strikingly unequal, and this inequality becomes still more remarkable if we compare months and weeks. Often, after a barren year, astronomers seem to wake up, and, in a space of some days, perceive three or four unknown asteroids; then they seem to relapse into slumber, and again, at the end of some months, rouse themselves for a new outbreak of discoveries. To be convinced of this extraordinary

* Of the National Observatory, Washington.

† Mr. Tuttle, of Harvard, has discovered another.

fact it is but necessary to cast an eye on the table of discoveries of asteroids. We shall there see more than one fortunate night in which science has been enriched with two of these minute bodies, and privileged weeks which have given us four of them. The 5th of October, 1855, for instance, M. Luther discovers Fides, and M. Goldschmidt, Atalanta. Erato springs into light at Berlin, and Titania in the United States, the 14th of September, 1860. The nights of the 9th and 12th had already been signalized by discoveries made by MM. Goldschmidt and Chacornac. April 26, 1861, Hesperia and Latona succeed one another at two hours' interval, and September 19, 1857, with a success unheard of in the annals of astronomy, M. Goldschmidt, for his own share, detects, very near one another, the *twin* planets Pales and Doris. Often the same planet, in the same night or nights but little remote, has been perceived by two and sometimes by three astronomers, observing from widely distant stations. It is in this way that M. Gasparis might dispute Irene with M. Hind, and Massilia with M. Chacornac. By a coincidence still more surprising, the 1st of March, 1854, Amphitrite is simultaneously discovered by MM. Marth, Chacornac, and Pogson, while, on his part, M. Luther discovers Bellona. There will be found in the table concurrences not less extraordinary in connexion with the names of Lutetia and Calliope, Themis and Phocœa, Pomona and Polymnia, Isis and Daphne. To what cause are we to attribute facts like these, too numerous to be fortuitous? Thus far, it must be acknowledged, astronomers have given no satisfactory explanation. By some it has been asked if we should not recognize herein an indication of cotemporaneous formations, and of condensation actually taking place in the cosmic ring which gravitates between Mars and Jupiter, and if this idea does not find its confirmation in the mysterious changes of the rings of Saturn, recently signalized by MM. Bond and Lassell; but this hypothesis appears to us rash, and, on the whole, unphilosophical.

V.

The observation of the small planets is so difficult, and the discoveries are almost all so recent, that the notions which astronomy has gained with respect to each of these bodies in particular are still very small, there being several whose elements are determined with so little certainty and precision that the differences between one table and another extend, not merely to seconds, but to minutes and sometimes to degrees. We might cite a planet, Daphne, for instance, whose orbit is so little known, that for four years, notwithstanding assiduous research, astronomers have not been able to rediscover it. Nevertheless, the results obtained up to this time, incomplete as they are, suffice to enable us to group the asteroids according to the analogies and differences which they present, to study them collectively and in their mutual relations. This study is founded, in great part, on the analysis of the numerical tables which will be found at the end of the present notice.

Humboldt has classified the planets, after certain natural charac-

ters, in three families. The four *superior* planets, Neptune, Uranus, Saturn, and Jupiter, are distinguished by considerable volume and slight density; the time of rotation about their axes is about ten hours, and from this there results in these bodies considerable flattening; moreover, of the twenty-two satellites of the solar system, twenty-one pertain to this group. The four *inferior* planets, Mars, the Earth, Venus, and Mercury, have, on the contrary, much smaller volumes and much greater density; they revolve on themselves in nearly twenty-four hours, are but little flattened, and possess, among all the four, but one satellite, the Moon.

It is between these two groups so distinct, that the singular family of the asteroids revolves. Their orbits, in general more eccentric and more inclined to the ecliptic than those of the ancient planets, their volumes much inferior to those of the smallest satellites, and above all their mean distances from the sun constantly intermediate between those of Mars and Jupiter, evidently make of these small bodies a planetary family very different from the two others, and seem, indeed, rightly to consign them to a common origin. Such, as has been said, was the first idea of Olbers, from the time of his observing Pallas, and though his hypothesis must needs have appeared less probable after the discovery of Vesta, the geometers judged it sufficiently worthy of attention to be submitted to calculation. We find in the *Connaissance des Temps* for 1814 a curious memoir, in which Lagrange determines that, taking into account the velocity of translation of the primitive planet, and considering the thirty-four degrees of inclination of the orbit of Pallas as the maximum inclination of the new orbits of each fragment, a force capable of communicating to these fragments a velocity equal to twenty times that of a 24-pound cannon ball would have sufficed, in order that each of them should pursue an elliptical orbit around the sun, the common intersection of the new planes passing at the point where the explosion had taken place. A geometer would not nowadays undertake this calculation; for an examination, however rapid, of the mean distances of the 70 [three] asteroids at present known, permits us no longer to believe that their orbits could ever have passed at the same point. These mean distances, in effect, which will be found expressed in radii of the earth's orbit in one of the columns of our tables, vary between the numbers 2.20 for Flora or Harmonia, and 3.45 for Maximiliana, one of the planets most recently discovered. This important difference corresponds to about fifty millions of leagues of four kilometers. What would it be if we should compare the extreme distances? We should see Phocœa and Melpomene approach the sun as near as 1.79 radii of the earth's orbit, while Euphrosyne and Maximiliana withdraw from that luminary to distances marked respectively by 3.83 and 3.93. What is usually called the *zone* of the small planets extends, therefore, over a width of ninety millions of leagues, that is, over a space greater than the distance of the sun from the inferior border of that zone. The zone of the interior planets is twice as narrow, and there is consequently no more reason for regarding the asteroids as fragments resulting from the explosion of a single planet, than there

would be for referring Mars, the Earth, Venus, and Mercury to a similar origin. It would be in vain to rely on the great eccentricities of the orbits with the view of instituting an inquiry, whether, notwithstanding the differences in their great axes, those orbits did not present some points sufficiently adjacent to lend a degree of probability to the hypothesis of Olbers. We should find twenty-five millions of leagues to be the least distance for the orbits of Harmonia and Doris, thirty millions for Mnemosyne and Flora, forty-five millions for Maximiliana and Ariana. It is true that the nodes and apsides change their places, and, notwithstanding the slowness of those displacements, it is possible that, some thousands of ages before the present era, the orbits in other relative situations may have presented points more approximate than at present. But in vain should we ascend the course of ages, or even arbitrarily modify the position of the planes in which the asteroids revolve; we shall still have to dispose of minimum distances of at least fifteen millions of leagues, since the aphelion of Nemausa, for instance, is but at 2.52 units of distance from the sun, while the perihelion distance of Mnemosyne is indicated by 2.82, and that of Maximiliana by 2.96. It cannot be admitted that the perturbations of the planetary system could have produced such difference, and the hypothesis of Olbers is thus shown to be absolutely irreconcileable with the data which we now possess with regard to the asteroids. Is it necessary on that account to renounce the idea of a common origin? Not so; for, if we admit, with Laplace, that the planets have been formed by the condensation of rings of vapor successively abandoned by the sun in cooling, it suffices, in order to explain the coexistence of all the asteroids between Mars and Jupiter, to suppose that there existed in one of the rings many simultaneous centres of attraction, and we must acknowledge, with M. Le Verrier, that the difficulty is not to account for the exception, but, on the contrary, to comprehend why it did not become the rule.

VI.

If science shall ever succeed in resolving these delicate questions, it will doubtless be by adopting as a basis the relations of form and position of the different planetary orbits. What we should propose at present is less to mark out the work than to inquire in what direction the future seems likely to hold a discovery in reserve for astronomers. For that purpose we must see if the comparison of analogous elements reveals the existence of any remarkable law.

DISTANCES FROM THE SUN AND THE EARTH.

Let us add to what has been just said on this subject in discussing the hypothesis of Olbers, that the mean of all the distances of the seventy asteroids from the sun is 2.645 radii of the earth's orbit, or about 105 millions of leagues; which is almost exactly the distance of Fides, and less than that of Ceres and Pallas which best corresponds with the law of Bode. Of the seventy orbits, thirty-eight have their greater axes below the mean, and thirty-two above—an

inequality readily explained; for the difficulty of discoveries increasing in proportion to remoteness from the sun, the planets known to us will naturally be more thronged together the nearer they are to that luminary. It is to be presumed, for the same reason, that the real mean is higher than that stated; for it is doubtful if existing instruments would enable us to discover an asteroid whose perihelion distance might be higher than three.

The distances of the small planets from the earth vary between widely extended limits, which may reach from one to five radii of the earth's orbit. The nearest approach evidently takes place at the instant of the star's opposition; the distance being then about 0.8 for Phocœa, Melpomene, Iris, and Flora, and rising to 1.8 for Mnemosyne and 1.9 for Maximiliana. It is only at this point of time, for the most part, that the discovery or even the observation of one of these minute bodies becomes possible. Hence we must hasten to calculate its elements, if we wish again to find it in the heavens, after an absence of several months. When the calculation is founded on observations either imperfect or made at too short intervals, it sometimes happens that the planet is lost.* Oftenest, however, succeeding observations permit us to rectify the errors of a first result; thus it was at first believed that Nysa would intersect the orbit of Mars, while, in fact, it is always at least fifteen millions of leagues beyond that planet. Nemausa promised still more. M. Valz had announced that it would pass at eight millions of leagues from the earth, and that some day it might even approach within three millions of leagues. Astronomers have been obliged to renounce this hope, and that to their great regret; for the oppositions of this little orb would have furnished them an excellent means of determining the distance of the earth from the sun, a base so essential and yet so inaccurately known for all the dimensions which we attribute to the solar system.

TIMES OF THE SIDEREAL AND THE SYNODAL REVOLUTIONS OF THE ASTEROIDS.

We know that by the third law of Kepler the sidereal revolution of a planet depends on the length of half the greater axis of its orbit. The number 2.645, which has been assigned, as above stated, for the mean planet, corresponds to a mean heliocentric movement of 824″.8, and to a sidereal revolution of 1,571 days, that is to say, of about $4\frac{1}{3}$ years. The shortest revolutions are those of Flora (1,192.9 days) and of Ariana (1,197.7 days;) the longest are those of Euphrosyne (2,048 days) and of Maximiliana (2,343 days, or more than six years.) We see that these numbers vary nearly as one to two. Of these planets sometimes two and even three have the duration of their year almost identical; thus between Metis (1,346.31 days) and Iris (1,346.46) the difference is but $3\frac{1}{2}$ hours, and is but that of one day between Asia (1,551 days) and Pseudo-Daphne, (1,552.) We may also remark

* This occurred in the case of Daphne. In spite of assiduous and laborious research, M. Goldschmidt has not been able to rediscover this planet; but, while thus engaged, he detected Pseudo-Daphne. This again having been lost in turn, he has but just succeeded in refinding it, (August 27, 1861,) after sounding the heavens for three months.

Pandora, (1,683.18 days,) Pallas, (1,683.86,) and Lœtitia, (1,684.8.) These numbers, it should be added, are far from being definitive. We have adopted the tables of M. Mædler, who inscribes the names of the calculators, besides the results they have obtained. Should a different catalogue be preferred, that, for instance, of the *Annuaire du Bureau des Longitudes*, these approximations might perhaps disappear, but we should find others quite as remarkable. It were to be wished, on that account, that the attention of astronomers should be directed, in preference, to those asteroids whose revolutions present, in point of duration, but slight differences; perhaps those differences will be still further diminished by a more rigorous calculation of elements. In any case, when their progression shall have brought into heliocentric conjunction two planets, describing their orbits in the same number of days, their prolonged proximity will compensate, no doubt, for the feebleness of their masses, and there must result perturbations of a singular nature—perhaps a libration, which will reduce their mean years to a perfect identity.

The synodal revolution of an asteroid is evidently so much the longer as its mean movement is more rapid. Thus Flora or Ariana come into opposition but nine times in thirteen years, while Euphrosyne or Maximiliana do so nine times in eleven years.

Eccentricities.—The orbits of the asteroids are, in general, much more eccentric than those of the elder planets. The lowest eccentricities (Concordia 0.040, Harmonia 0.046,) are three times greater than those of the earth; the highest (Polymnia 0.338, Asia 0.320,) are almost equal to that of the comet of Faye. On the whole, of the 70 orbits now known, 18 are more eccentric than the orbit of Mercury, (0.2056,) 8 less so than the orbit of Mars, (0.096,) and the rest are of intermediate eccentricities. Hence it results that if the small planets have, like the great, a daily movement about an axis more or less inclined to the plane of their orbits, the duration of seasons must be there very unequal, and the temperature, for one of their hemispheres, much more extreme than on the earth. Polymnia, for instance, is twice as near the sun at its perihelion as at its aphelion; the heat and light, therefore, which fall on its entire surface vary in the ratio of 4 to 1: the apparent diameter of the sun is then 8′ 27″ at its maximum and 4′ 11″ at its minimum, while, for the earth, the extreme numbers differ by only $\frac{1}{30}$ of their amount. From this it results that, if the equator of Polymnia is not very much inclined to its orbit, the seasons there depend, above all, on the distances from the sun, which circumstance determines winter or summer for all the points of the planet at the same time.

VII.

DISTRIBUTION OF THE REMARKABLE POINTS OF THE ORBITS ON THE CELESTIAL SPHERE.

It is sufficient to cast an eye on the columns in which are inscribed the longitudes of the perihelia, or those of the ascending nodes, to see that these longitudes are not distributed after a uniform manner

between 0° and 360°. This, astronomers had already remarked, when as yet they were acquainted with but from 12 to 15 asteroids, and it has been confirmed by further discoveries: it is a fact highly worthy of attention, on account of the consequences which may perhaps be some day derived from it in relation to the origin and formation of the planets. Unfortunately it does not seem easy to detect the law of the phenomenon; but in this there is nothing surprising. For, on one hand, the perihelia and nodes are constantly being displaced, and, on the other, the plane of the ecliptic, itself movable, is unimportant in the general aggregate of the solar system. It was natural, then, to inquire whether we might not arrive at a more marked convergence, by substituting for the lines of the nodes of the planetary orbits the intersections of those orbits with a fundamental plane, such as the invariable plane of the solar system, or even the equator of the sun itself. At the epoch when MM. Mædler, Cooper, d'Arrest, &c., undertook these researches and others of the same kind, their investigations embraced scarcely half the planets now known, nor did they, moreover, pursue a uniform method. By M. Burat and myself all the calculations of these astronomers have been repeated, adopting the numbers which appeared to us most worthy of confidence, as well for the elements of the asteroids as for the determination of the solar equator or invariable plane. We have, besides, conformed to a constant rule in our search for the *centre of convergence* of a system of lines of the same kind. This rule, at once simple and natural, consists in regarding these lines as so many equal forces and in seeking the direction of their resultant. The same calculation gives also the quantity of this resultant, a quantity evidently so much the more considerable as the convergence is more marked; for this reason we give the name of *coefficient of convergence* to the quotient of the total resultant by the sum of the components.

Convergence of the perihelia.—The rule just indicated gives us 47° 20′ for the longitude of the perihelia on the celestial sphere, and 0,255 for a coefficient of convergence. The hemisphere, which has for its pole the point thus determined, comprehends the perihelia of 46 asteroids, having a mean eccentricity marked by 0,168. The opposite hemisphere contains but 24 perihelia, and the mean eccentricity of the corresponding orbits is but 0,137. The centre of convergence determined by M. Mædler for the first 58 asteroids had for its longitude 52° 25′, and approaches, consequently, much more than ours the group of the Pleiades, where, as is known, M. Mædler places the centre of the immense orbit described in space by the sun followed by its retinue of planets.

Convergence of ascending nodes.—The point of convergence of the 70 ascending nodes, on the plane of the ecliptic, has for its longitude 135° 53′, and the coefficient of convergence is 0,256, very nearly as for the perihelia. Forty-six ascending nodes are found in the hemisphere which has for its pole the centre of convergence, and 24 in the opposite hemisphere. The ratio of these two numbers is the same as for the perihelia, and we will recall, in this connexion, a singular remark which was made by M. Cooper some years ago, that

in considering the 10, 20, 30, 40, or 50 planets first known, we shall always find, nearly to a unit, the same number of perihelia and of ascending nodes in the respective hemispheres where these points have their centres of convergence.

The inequality in the distribution of the ascending nodes on the celestial sphere is still more marked when we take the angular subdivisions lower than 90°. If we divide, for instance, the ecliptic into six arcs of 60°, reckoning from the fifth degree of longitude, we find:

From 5° to 65°	10	ascending nodes.
From 65° to 125°	12	do.
From 125° to 185°	23	do.
From 185° to 245°	10	do.
From 245° to 305°	6	do.
From 305° to 5°	9	do.

The general table shows, moreover, independently of the predominance of nodes in one part of the heavens, a general disposition of these nodes in partial groups, isolated one from the other; for instance, towards the 8th degree of longitude, the 43d, the 68th, the 80th, &c.

It may be asked, as we have already observed, whether a more perspicuous law might not be obtained by substituting for the plane of the ecliptic the invariable plane or the plane of the solar equator. We have made this double calculation for each of the 70 planets, beginning with a determination as exact as possible of the position of the invariable plane—that is to say, by taking account, in conformity with the remarks of Poinsot, of the areas which arise from the rotation of the sun and the great planets. This plane, whose elements differ little from those which Laplace had adopted, is only inclined about 1° 41′ to the ecliptic. It hence results that the nodes group themselves on the two planes much after the same manner, and that the consideration of the invariable plane casts no new light on the question.

At first view it would seem to be quite otherwise with regard to the plane of the solar equator. As early as the beginning of the last century, (*Memoires de l'Academie des Sciences*, 1734,) Cassini had observed that the intersections of the equator of the sun with the orbits of Venus, the earth, Mars, Jupiter, and Saturn, grouped themselves on an arc of less than 25 degrees in extent. In 1851 M. d'Arrest made an analogous calculation for the first thirteen asteroids, and found that, notwithstanding a more considerable mean divergence of the ascending nodes on the solar equator, eleven of those nodes out of thirteen were situated in the same hemisphere with the nodes of the ancient planets. We have taken up and completed the work, as well for the eight great planets now known as for the 70 asteroids, and we give the results at which we have arrived, while adopting for the position of the solar equator the numbers ascertained by M. Langier:

Longitude of the ascending node of the solar equator on the ecliptic	75° 8′
Inclination	7° 9′

	For the large planets.	For the small planets.
Arc of the solar equator, reckoned from the ascending node of that equator on the ecliptic to the centre of convergence	184° 9′	164° 56′
Coefficient of convergence	0,904	0,624

These coefficients are, we see, much more considerable than those found above. Moreover, of the 70 ascending nodes, 62 are situated in the same hemisphere with the centre of convergence, and only eight in the opposite hemisphere. But, notwithstanding the apparent singularity of this result, a little reflection will suffice considerably to diminish its importance, for it arises, in great measure, from the fact that the planetary orbits are less inclined to one another than to the equator of the sun. We perceive, in effect, without difficulty, *a priori*, that closely adjacent planes, conformably with lines closely approximate, must intersect another plane, which forms with each of them an angle of some degrees. The same considerations explain why the convergence is more marked in regard to the great than the small planets. It must be admitted, then, that this phenomenon has not the importance attributed to it by Cassini and some modern astronomers; but the calculation, of which we have just given the results, is not less useful on that account for determining, better than the nodes on the ecliptic could do, the position in space of the *mean orbit* of the asteroids, of which the masses should be considered as equal. We may, with M. d'Arrest, regard as the plane of the mean orbit the plane which cuts the solar ecliptic according to the line of convergence, under an inclination equal to the mean of the inclinations of all the asteroids; that is to say, under an angle of 9° 58′. No doubt the inclination thus determined is not absolute, and would change slightly at each new discovery. But as we find results but little different when the calculation is confined in succession to the 30, 40, or 60 first known asteroids, we are justified in concluding that these results are sufficiently approximate to that which the whole number of the small planets would give, if all were discovered.

RELATION BETWEEN THE ECCENTRICITIES AND INCLINATIONS OF THE ORBITS.

M. d'Arrest, while remarking that great inclination is not always accompanied by great eccentricity, and that a consideration of the separate orbits guides us to no relation between these two elements, conceives, nevertheless, that if these orbits are suitably grouped in the order of their inclinations to the solar equator, the mean of the inclinations, for each group, would increase with the mean of the eccentricities; he has even arrived, for the first thirteen planets grouped by fours and by threes, at the following empirical formula, in which i expresses the mean inclination, and e the mean eccentricity of each group:

$$e = 0.0851 + 0.0068\, i.$$

M. Littrow, who has given this formula in his Astronomy, (1854,)

adds that it would probably be confirmed by the discovery of new asteroids. The results obtained by us are not in accordance with this supposition. In whatever manner we may group the orbits, it is impossible to arrive at any law for inclinations below 12 or 13 degrees. The sole remark which remains true is, that the orbits, much inclined to the solar equator, are also in general very eccentric; but as, on the other hand, these orbits are much inclined to the ecliptic as well as to the solar equator, we see that there is nothing in the preceding remark which can be specially relative to this last plane. Still, exceptions to the rule ought to be pointed out; for instance, the most eccentric of all the orbits, that of Polymnia, makes but an angle of two degrees with the ecliptic, and of six with the solar equator; while the orbit of Egeria possesses, with inclinations of 16 and 11 degrees to these same planes, an eccentricity of only 0.089.

VIII.

INTERLACEMENT OF THE ORBITS AND APPROXIMATIONS OF THE SMALL PLANETS.

If we compare two by two the positions of the orbits of the asteroids, we see that it is rarely that one of them is completely enveloped by another; most frequently they are intertwined after the manner of the rings of a chain. M. d'Arrest was the first to remark that if we represented all the orbits under the form of material hoops, these hoops would be so intervolved that we might by means of one of them raise all the rest. When but thirteen of the small planets were yet known, they seemed to form two separate groups, between which the planet Iris served as a connecting link; but at present this remark is no longer applicable.

M. Littrow, the learned director of the Observatory of Vienna, has particularly occupied himself with the research of the *physical conjunctions* which, from this time till the end of the century, may lead to remarkable approximations among the asteroids. The problem consists of two parts: 1st, to find the shortest line which can be drawn between two orbits; 2dly, to calculate the epoch at which the planets describing those orbits shall pass nearly simultaneously by the two extremities of that line. The first part of the problem is the most important and most difficult. M. Littrow has investigated it by a graphic method, which consists in seeking the intersection and mutual inclination of the two orbits under consideration, tracing out the two curves, taking the plane of one of them for the plane of projection, and describing the other by the processes of descriptive geometry. The astronomer of Vienna has thus found for the 42 orbits submitted to discussion, 548 mutual distances less than the tenth part of the radius of the terrestrial orbit—that is, than four millions of leagues. In more than eighty cases the elements of the orbits are so completely different that it is impossible to foresee between these curves any remarkable approximation, and yet the graphic method spoken of brings them nearly to an intersection. The cases of double ap-

proximations are computed at one hundred and eight; sometimes two orbits continue very near one another through a great part of their circuit; thus, for a space of 192 degrees, the orbits of Euterpe and Massalia are never separated more than a tenth part of the half of the greater axis of the earth's orbit. The approximations being once indicated by the graphic method, we can determine them more exactly by means of calculation, and it is easy afterwards to investigate the period at which two planets must pass at the same time by the nearest points of their respective orbits. M. Littrow has thus found that the 42 planets he has studied would, in the decennial period, 1858 to 1867, undergo eighteen *physical conjunctions*, to which he has invited the attention of astronomers. It is readily conceived that the number of these conjunctions increases by a law much more rapid than the number of new planets in such sort that, if we should recommence the calculation for the 70 planets now known, we should doubtless find many other approximations of the same kind; but this would require long and tedious application, without leading to definitive results as long as there shall remain asteroids to be discovered. There are cases, however, where the investigation of physical conjunctions only requires a graphic construction extremely simple; such is the case where the two orbits to be considered have very nearly the same line of nodes and the same inclination to the ecliptic. We may particularly specify the orbits of Fides and Maïa; their elements present less difference than often exists between the elements of one and the same planet, as given by different calculators. This is shown by a comparison of the two following tables:

	Fides.	Maïa.
Longitude of the ascending node	8° 12′	8° 12′
Inclination	3° 7′	3° 5′
Semi-great axis	2,642	2,654
Eccentricity	0,174	0,155
Longitude of perihelion	65° 7′	43° 54′

If we disregard the mutual inclination of the two orbits, which is but of two minutes, we may trace these two orbits on the same plane, and we thus find two points of intersection, one of which almost coincides with the perihelion of Maïa. The distance between the two curves rises at no point beyond the twentieth part of the radius of the terrestrial orbit. At the present time the mean longitudes of the two planets differ about forty degrees, but this difference constantly diminishes, though slowly. When it shall have disappeared, the two planets, notwithstanding their inconsiderable mass, and by reason of their continual nearness, will exert upon one another an action, perhaps, sufficiently strong to unite them in one single body, or cause them to revolve, as the components of a double star, around their common centre of gravity.

IX.

ASPECT, PHYSICAL CONSTITUTION, AND REAL MAGNITUDE OF THE ASTEROIDS.

At the commencement of the present century Schrœter devoted himself particularly to the telescopic study of the four planets Ceres, Pallas, Juno, and Vesta. The care which this astronomer employed in his observations gave great importance to the results of his labors. Hence these results were long admitted without dispute, and we find them reproduced in the most recent French treatises, although, for the most part, they have been shown some years ago to be inexact. Thus Schrœter had deduced from multiplied measurements the apparent diameters of the four planets, and had concluded that the largest amongst them, Pallas, presented nearly the same magnitude as the moon. William Herschel, on the other hand, obtained numbers considerably lower, and yet these numbers were still too high, by reason of the effects of irradiation. This we ascertain from the observations made, under unusually favorable circumstances, by MM. Mædler and Lamont, with the aid of the excellent refractors of Dorpat and Munich. From the opposition of 1836, M. Lamont found 0″.51 for the angular diameter of Pallas, at the mean distance 2.77, which gives about 250 leagues for the real diameter of the planet. In April and May, 1847, M. Mædler found in like manner one hundred leagues for the diameter of Vesta. It is equally to the effects of the irradiation that we must refer the cause of the vaporous appearances assumed by Ceres and Pallas in the telescope of Schrœter; appearances so marked that the astronomer of Lilienthal attributed to those planets atmospheres 200 leagues in height. The great refractor of Dorpat exhibits the disc of Pallas as clear as that of Vesta, and thus vanishes one of the analogies which has been often insisted upon between the comets and the asteroids.

The existence of a very considerable and turbulent atmosphere would have sufficed, according to Schrœter, to explain the remarkable variations which that astronomer had detected from day to day in the brilliancy of Pallas or Ceres. At present it is necessary to seek elsewhere the cause of this phenomenon, the reality of which has in the mean time been confirmed by later observations. It is probable that the asteroids, as an effect of their daily movement, present to us in succession, regions unequally adapted to reflect the light of the sun. But differences of this nature do not, according to M. Littrow, sufficiently account for the rapidity and extent of the variations observed, and, above all, for the truly stellar brilliancy with which the planet Vesta sometimes sparkles, even when its disc presents no appreciable dimensions. The astronomer of Vienna thinks that the asteroids are of irregular or polyhedric forms, and that they sometimes turn towards us lustrous facets like those of the diamond, or even endowed perhaps with an intrinsic light. However this may be, these variations of brightness are observed in several of the

asteroids discovered within fifteen years. For instance, M. Goldschmidt observed that on the 26th January, 1858, Pales was invisible through a telescope which showed stars of the twelfth magnitude, while on the 2d of February following, this same planet equalled in brightness neighboring stars of the eleventh magnitude.

We have just seen that the attempts of Schrœter, Herschel, Lamont, and Mædler to arrive at a direct measurement of the diameters of Pallas, Ceres, or Vesta, have yielded results but little accordant. With regard to the other asteroids such measurements have not been even attempted; but the approximative value of the real dimensions of each of them has been obtained from indirect considerations. In fact, the *magnitude* under which a star shining by a reflected light is to be classed, depends evidently on the *distance of that star from the sun*, on *its distance from the earth*, on *its real diameter*, and on *the reflective power* (albedo) of its surface. Four of these quantities being given, we can find the fifth. For the ancient planets, the *albedo* alone is unknown; for the magnitude of each of them is easily expressed in numbers by taking for bases the photometric measurements of MM. Steinheil and Seidel. We thus find that the *albedo* is nearly the same in Saturn, Jupiter, Venus, and Mercury; a little inferior in Mars, on account of the red color of that star. As the asteroids, moreover, have in general the white tint of the four first planets, we see that it is allowable to suppose, also, that they have the same reflective power. Hence the real diameter of these small bodies will alone remain unknown.

This being granted, it results, from the investigations of M. Seidel, that the *magnitude* of a star increases by one unit when its distance from the earth increases in the ratio of 1 to 1.6. From this M. Argelander has deduced a very simple formula.

Let:

$b = 1.6$;
a, the semi-axis major of the orbit of a planet;
r, the mean distance of that planet from the sun;
$\triangle$, the mean distance of that planet from the earth;
M, the magnitude of the star for $r = a$ and $\triangle = a - 1$;
m, the magnitude of the star for $r = r_0$ and $\triangle = \triangle_0$;
d, the real diameter expressed in leagues of 4 kilometers.

We shall have:

$$\log. d = 2{,}7913 - m \log. b + \log. r_0 + \log. \triangle_0,$$
$$= 2{,}7913 - \text{M} \log. b + \log. a + \log. (a - 1.)$$

This formula gives the following table for the *magnitudes* of 50 asteroids and for their real diameters:

Names.	M.	d.	Names.	M.	d.
		leagues.			*leagues.*
Vesta	6.5	105	Euterpe	10.2	15
Ceres	7.4	89	Bellona	10.3	24
Pallas	8.2	61	Lutetia	10.3	16
Iris	8.3	39	Phocæa	10.5	14
Hebe	8.4	39	Thetis	10.6	15
Eunomia	8.5	46	Fides	10.7	18
Lætitia	8.6	49	Nysa	10.7	17
Flora	8.8	25	Thalia	10.7	16
Juno	8.9	42	Calliope	10.8	20
Metis	8.9	30	Pales	10.8	18
Harmonia	9.1	40	Proserpina	10.8	16
Amphitrite	9.1	33	Leda	10.9	15
Massilia	9.1	27	Isis	10.9	10
Parthenope	9.4	25	Pomona	11.0	13
Melpomene	9.4	21	Euphrosyne	11.3	20
Egeria	9.4	28	Polymnia	11.3	14
Hygeia	9.5	45	Doris	11.4	21
Fortuna	9.5	24	Aglaia	11.4	15
Irene	9.6	27	Circe	11.5	9
Urania	9.7	20	Eugenia	11.6	11
Psyche	9.8	86	Themis	12.1	14
Astræa	9.8	24	Leucothoe	12.1	9
Victoria	10.0	21	Verginia	12.4	8
Ariana	10.0	14	Hestia	12.5	6
Daphne	10.2	17	Atalanta	12.9	8

It will be remarked that this calculation gives for the diameter of Vesta nearly the same number as the direct measurement, but a much less number for the diameter of Pallas. We are struck, also, at the extreme smallness of some asteroids, such as Hestia, Verginia, Atalanta, Circe, Leucothoe, &c., which have a radius of scarcely three or four leagues, and whose surface is less than that of one of our smallest departments. A good walker might make the tour of one of these microscopic globes in a day. With an equal density, gravitation at its surface would be three or four times less than on the earth.

In short, if we take our computation from the preceding table, we find that the united volumes of the 50 planets above enumerated would give scarcely the two-hundredth part of the volume of our satellite.

X.

PERTURBATIONS OF THE ASTEROIDS, ETC.

The investigation of the perturbations of the asteroids has been as yet scarcely sketched out; the extreme difficulty of the problem results, on the one hand, from the small number of observations of which astronomers can avail themselves, and, on the other, from the

magnitude of the inclinations and eccentricities of the orbits. Hence, as has been already said, there are several of these orbits of which the elements are at present known with but very little exactness. A more rigorous determination of these elements, and the investigation of their secular variations, constitute one identical problem whose solution exacts the employment of new methods. There have been constructed, indeed, from year to year since the beginning of the century, tables of the four older asteroids by following the processes of interpolation indicated by Gauss and Encke. MM. Brunow and Hansen have even extended these processes to some of the more recently discovered planets, such as Flora. But we arrive in this way only with great difficulty at the analytic expression of the periodic or secular inequalities. M. Hansen has recently published a new theory of the planetary perturbations, the advantages of which are pre-eminently decisive when the orbits are very much inclined or very eccentric, and the distinguished astronomer has himself applied this theory to the calculation of the perturbations of Egeria. M. Le Verrier, on his part, has discovered the great inequality of Pallas by a method wholly different, to which M. Hoüel has lately added some improvements which facilitate its application. Such are very nearly the attempts which have been made by geometers up to the present time to master the theory of the small planets.

We have here as well one of the most recent as most interesting of astronomical questions. The perturbations, necessarily very great, which result from the attraction exerted by Jupiter, will give, when they shall have been calculated, a very exact determination of the mass of that planet. It will be more difficult to calculate the individual masses of the asteroids, but we shall arrive probably without excessive difficulty at a knowledge of the precise value of their combined masses. M. Le Verrier has already deduced from his investigations respecting Mercury and Mars the higher limit of that value, and it is to the following formula that he has himself reduced his remarkable conclusions :

1st. Besides the planets Mercury, Venus, the Earth, and Mars, there exists between the Sun and Mercury a ring of asteroids which collectively constitute a mass comparable to that of Mercury itself.

2d. At the distance of the earth from the sun there is found a second ring of asteroids whose mass is at most equal to the tenth part of the mass of the earth.

3d. *The total mass of the asteroids comprised between Mars and Jupiter is, at most, equal to the third of the mass of the earth.*

4th. The masses of the two latter groups are complementary one of the other. Ten times the mass of the group situated at the distance of the earth, *plus* three times the total mass of the small planets situated between Mars and Jupiter, form a sum equal to the mass of the earth.

If we compare these results of the calculus with what has been said above of the smallness of the volume of the asteroids, we shall arrive at a remarkable consequence. By supposing that the mean density of these bodies is equal with that of the earth, the united

masses of those with which we are acquainted would, at the most, form the ten-thousandth part of the mass of our globe; that is to say, about the two-thousandth part of the total mass of the cosmic ring comprised between Mars and Jupiter. The number of the unknown asteroids would then be at least two thousand times more considerable than the number of those already discovered. It is in this sense that M. Le Verrier says that these small bodies are indefinite in number, and it is on this account especially that he is opposed to the designation of each of them by a particular name, since it will be necessary some day to stop doing so. But to this M. Hind and almost all other astronomers answer that the number of the asteroids which our instruments will enable us to perceive is probably sufficiently restricted, and that there would be great inconvenience in substituting simple ordinal numbers for the present nomenclature, on account of the inevitable confusion which would result therefrom. We are ourselves of this opinion, and we may perhaps be permitted to add, as corroborative of the good reasons already given, that if the proposal of M. Le Verrier were adopted, all investigations of the nature of that which we now publish, after the example of what has been often done in Germany, would by that means become almost impossible.

We terminate this paper with the table of the elements of the small planets, prepared from the last edition of the *Astronomy* of M. Mædler, and the last numbers of the *Astronomische Nachrichten.*

Synoptical table of the elements of the small planets.

No.	Names.	Authors of the discovery.	Date of the discovery.	Mean distance from the sun.	Times of revolution.	Eccentricity.	Inclination.	Longitude of the ascending node.	Longitude of the perihelion.
					Days.		° ′	° ′	° ′
1	Ceres	Piazzi	Jan. 1, 1801	2,766	1680,26	0,080	10 36	80 50	149 27
2	Pallas	Olbers	Mar. 28, 1802	2,770	1683,86	239	34 42	172 40	122 10
3	Juno	Harding	Sept. 1, 1804	2,669	1593,21	255	13 3	171 1	54 5
4	Vesta	Olbers	Mar. 29, 1807	2,360	1324,84	090	7 8	103 26	250 21
5	Astræa	Hencke	Dec. 8, 1845	2,576	1510,55	190	5 19	141 33	134 44
6	Hebe	Hencke	July 1, 1847	2,425	1379,63	0,201	14 46	138 36	15 13
7	Iris	Hind	Aug. 13, 1847	2,386	1346,46	231	5 27	259 47	41 29
8	Flora	Hind	Oct. 18, 1847	2,201	1192,99	156	5 53	110 28	33 4
9	Metis	Graham	April 25, 1848	2,386	1346,21	123	5 36	68 33	71 10
10	Hygeia	Gasparis	April 12, 1849	3,149	2041,40	100	3 47	287 45	227 55
11	Parthenope	Gasparis	May 11, 1850	2,452	1402.91	0,099	4 37	125 5	316 11
12	Victoria	Hind	Sept. 13, 1850	2,334	1302,71	219	8 23	235 42	301 47
13	Egeria	Gasparis	Nov. 2, 1850	2,575	1509,72	088	16 32	43 20	119 32
14	Irene	Hind Gasparis	May 19, 1851 May 23, 1851	2,589	1522,01	165	9 7	86 42	179 29
15	Eunomia	Gasparis	July 29, 1851	2,643	1569,37	188	11 44	294 1	27 52
16	Psyche	Gasparis	Mar. 17, 1852	2,926	1828,41	0,135	3 4	150 37	12 35
17	Thetis	Luther	April 17, 1852	2,474	1421,07	126	5 35	125 30	259 26
18	Melpomene	Hind	June 24, 1852	2,296	1270,61	217	10 9	150 6	15 19
19	Fortuna	Hind	Aug. 22, 1852	2,441	1393,29	158	1 32	211 32	30 24
20	Massilia	Gasparis Chacornac	Sept. 19, 1852 Sept. 20, 1852	2,409	1365,96	143	0 41	206 43	98 36
21	Lutetia	Goldschmidt	Nov. 15, 1852	2,435	1388,21	0,162	3 5	80 33	327 8
22	Calliope	Hind	Nov. 16, 1852	2,909	1812,28	103	13 44	66 43	58 13
23	Thalia	Hind	Dec. 15, 1852	2,625	1553,39	235	10 14	68 1	123 16
24	Themis	Gasparis	April 5, 1853	3,142	2034,22	117	0 48	36 11	139 9
25	Phocæa	Chacornac	April 6, 1853	2,402	1359,99	253	21 35	214 5	302 55

Synoptical table of the elements of the small planets—Continued.

No.	Names.	Authors of the discovery.	Date of the discovery.	Mean distance from the sun.	Time of revolution.	Eccentricity.	Inclination.	Longitude of the ascending node.	Longitude of the perihelion.
					Days.		° ′	° ′	° ′
26	Proserpina	Luther	May 5, 1853	2,656	1581,08	0,087	3 36	45 56	235 20
27	Euterpe.......	Hind	Nov. 8, 1853	2,347	1313,55	172	1 35	93 45	87 39
28	Bellona.......	Luther	Mar. 1, 1854	2,778	1691,57	150	9 21	144 40	122 26
29	Amphitrite ..	Marth............. Pogson .... Chacornac	Mar. 1, 1854 Mar. 1, 1854 Mar. 2, 1854	2,555	1491,58	072	6 7	356 27	56 39
30	Urania........	Hind	July 22, 1854	2,364	1327,75	127	2 6	308 15	31 24
31	Euphrosyne...	Ferguson	Sept. 1, 1854	3,156	2048,01	0,216	26 25	81 29	93 55
32	Pomona	Goldschmidt......	Oct. 26, 1854	2,586	1519,56	082	5 29	220 52	194 27
33	Polymnia	Chacornac	Oct. 28, 1854	2,864	1770,89	337	1 57	9 19	340 46
34	Circe	Chacornac	April 6, 1855	2,688	1609,46	105	5 26	184 49	149 49
35	Lencothea	Luther	April 19, 1855	2,985	1883,66	222	8 12	356 11	198 38
36	Atalanta.......	Goldschmidt......	Oct. 5, 1855	2,749	1664,50	0,298	18 42	359 12	42 26
37	Fides	Luther	Oct. 5, 1855	2,642	1568,64	175	3 7	8 13	66 8
38	Leda	Chacornac	Jan. 12, 1856	2,740	1656,58	155	6 58	296 31	100 48
39	Lætitia	Chacornac	Feb. 8, 1856	2,771	1684,84	111	10 21	157 23	2 11
40	Harmonia	Goldschmidt......	Mar. 1, 1856	2,268	1247,45	046	4 16	93 33	0 58
41	Daphne	Goldschmidt......	May 22, 1856	2,400	1358,30	0,202	15 48	180 9	230 24
42	Isis	Pogson...........	May 23, 1856	2,440	1392,20	225	8 35	84 30	318 0
43	Ariana........	Pogson...........	April 15, 1857	2,204	1197,74	167	3 28	264 32	277 16
44	Nysa	Goldschmidt......	May 27, 1857	2,424	1378,59	149	3 42	131 3	111 39
45	Eugenia	Goldschmidt......	June 28, 1857	2,716	1634,72	081	6 35	148 7	228 53
46	Hestia	Pogson	Aug. 16, 1857	2,518	1459,24	0,144	2 17	181 31	354 26
47	Aglaia	Luther	Sept. 15, 1857	2,883	1788,11	128	5 0	4 33	314 33
48	Doris	Goldschmidt......	Sept. 19, 1857	3,109	1997,90	077	6 30	185 16	76 54
49	Pales	Goldschmidt......	Sept. 19, 1857	3,086	1980,20	238	3 8	290 31	32 52
50	Verginia	Ferguson .... Luther	Oct. 4, 1857 Oct. 19, 1857	2,649	1574,43	287	2 48	173 34	10 2
51	Nemausa......	Laurent	Jan. 22, 1858	2,378	1339,33	0,063	10 15	175 39	190 14
52	Europa	Goldschmidt......	Feb. 4, 1858	3,100	1993,47	101	7 25	129 59	102 4
53	Calypso.......	Luther	April 4, 1858	2,610	1540,45	213	5 8	144 16	91 34
54	Alexandra	Luther	Sept. 10, 1858	2,708	1627,31	199	11 47	313 52	293 40
55	Pandora	Searle	Sept. 10, 1858	2,769	1683,18	139	7 21	10 56	10 10
56	Pseudo Daphne	Goldschmidt......	Sept. 13, 1858	2,583	1552,00	0,227	7 56	194 58	295 1
57	Mnemosyne...	Luther	Jan. 1, 1860	3,155	2047,10	106	15 4	200 9	53 25
58	Concordia	Luther	Jan. 10, 1860	2,693	1619,01	040	5 3	161 22	177 56
59	?....	Chacornac	Sept. 9, 1860	2,605	1501	196	6 36	167 9	337 52
60	Danae	Goldschmidt......	Sept. 12, 1860	2,975	1875	163	18 17	334 19	340 9
61	Echo	Ferguson.........	Sept. 14, 1860	2,392	1352	0,185	3 34	191 58	98 28
62	Erato..........	Forster & Lesser..	Sept. 14, 1860	3,124	2019	169	2 13	126 41	26 14
63	Ausonia	Gasparis..........	Feb. 10, 1861	2,397	1356	128	5 45	338 3	268 7
64	Angelina......	Tempel	Mar. 4, 1861	2,678	1602	125	1 20	311 2	126 28
65	Maximiliana ..	Tempel	Mar. 8, 1861	3,452	2343	141	3 29	159 9	254 37
66	Maia	Tuttle............	April 9, 1861	2,654	1580	0,155	3 5	8 12	43 54
67	Asia..........	Pogson	April 17, 1861	2,582	1516	320	6 34	204 39	321 30
68	Latona	Luther	April 26, 1861	2,775	1688	204	7 58	44 50	346 00
69	Hesperia	Schiaparelli	April 26, 1861	3,075	1958	194	8 27	186 54	125 42
70	Panopea	Goldschmidt......	May 5, 1861	2,499	1445	071	15 17	47 24	85 28?
71	Niobe.........	Luther	Aug. 13, 1861	2,756	1671	0,173	23 18	316 18	221 59
72	Feronia	Safford.	Feb. —, 1862	2,145	1148	0,119	5 23	208 1	329 22
73	....	Tuttle............	April 7, 1862	No elem	ents have	yet been	publish	ed.	

[It will be seen that we have added to the original list three asteroids discovered since the middle of 1861, for an account of which we are indebted to Professor Hubbard, of the National Observatory.—*Sec. Smith. Inst.*]

DIRECTIONS FOR OBSERVING

THE SCINTILLATION OF THE STARS.

By CH. DUFOUR,

PROFESSOR AT MORGES, SWITZERLAND.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION, FROM THE "REPERTORIUM FUR METEOROLOGIE," ETC.: DORPAT, 1859.

EVEN to the most recent times the scintillation of the stars has not formed the subject of any series of observations. We find here and there, it is true, some isolated observations, and a few persons have proposed different explanations of this phenomenon, but as yet no course of investigation had been seriously prosecuted. I may claim to be the first who undertook a labor of this kind. My observations at Morges in 1852 were at first but a succession of attempts, but from 1853 to the present moment I have allowed no evening, when the stars could be seen, to pass without carefully observing the scintillation. And now, after the dedication of six years to such inquiries, I feel authorized to pronounce that this study is important, and well deserves to occupy a place among meteorological observations.

But in order that the results may be general and more complete, it is desirable that systematic observations analogous to those which I have undertaken should be prosecuted elsewhere in other climates and under varied meteorological circumstances. There can, at present, but four stations be counted where I am justified in hoping that this inquiry has been entered upon and will be persistently carried on:

1. Morges, Switzerland, 46° 30′ north latitude, 4° 9′ east longitude from Paris. Since 1853 I have taken at this station nearly 24,000 observations of scintillation. The principal results thus far obtained from these numerous observations have been published either in the "Comptes Rendus" of the Academy of Belgium, or in those of the Academy of Paris, or in the Notices of the Astronomical Society of London, or in the Bulletins of the Vaudoise Society of the Natural Sciences. I propose soon to communicate some of these observations to the "Repertorium," &c., as a sequel and complement to the present directions:

2. The great St. Bernard, in the Alps, at an altitude of 2,480 meters. The monks, who pass the whole year in these elevated regions on the borders of perpetual snow, have consented to continue

the observations which I began there in the summer of 1856, during a sojourn amongst them.

3. Cairo, where Mahmoud Effendi, director of the observatory, has commenced or will immediately commence a series of observations analogous to that at Morges.

4. Peak of Teneriffe, where Mr. Piazzi Smyth, director of the observatory of Edinburg, has already on one occasion spent several months with a view to scientific inquiries. He has promised me that, if, as he hopes, it shall be in his power to continue his researches on this isolated mountain, the scintillation of the stars will be a subject which will engage his particular attention.

Four stations, however, are but a small affair for the whole surface of the globe; among others, there are certain climates and countries with regard to which no information is accessible, for example:

The torrid zone.—There is on this zone no point of observation. The Peak of Teneriffe approaches it more closely than any other, but it would be important to know how the stars scintillate in the view of an observer situated between the tropics, in the hottest and probably the most humid countries of the globe.

The southern hemisphere.—Observations made beneath the skies of the other hemisphere would also possess great interest; for not only would the observer be placed in very different meteorological conditions, but he could observe certain stars which are always invisible to us, among others, Achernar and Canopus. The beautiful stars of that hemisphere, Sirius and Rigel, which we see only in winter, are visible to the south of the equator during the hot season; they pass, moreover, nearer to the zenith. It would be interesting to see how the scintillation is modified by this assemblage of circumstances.

The boreal regions.—The countries, however, which would afford the best opportunities for valuable observations are those situated to the north. It would be of consequence to know how the stars scintillate during the cold and serene nights of Siberia, or even of Russia, in Europe—what appearance they present in this respect on the polar seas during those long nights which last for several consecutive months. Hence, I particularly commend this study to the numerous savans who live in Russia, who, from Dorpat to Archangel, from the borders of the Frozen ocean to the shores of the Black sea and the Caspian, might collect a numerous series of important observations.

I commend this study also to explorers who may be called to pass entire winters amidst the ices of the pole. I greatly regret that my own observations did not commence ten years sooner, as I might have had the opportunity of pointing out this line of inquiry to the numerous navigators who have traversed the polar seas in search of Sir John Franklin and been imprisoned whole winters by the ice. Such expeditions may be, and probably will be renewed. I take the liberty of calling the attention of these future explorers to the scintillation of the stars as a department of research which may prove in their hands fertile in interesting results.

But to save observers from fruitless trials, and to place at their service the experience which I have acquired from the numerous observations made at Morges, as well as to render the indications of one observer comparable with those of another, I think it proper to recommend the following instructions:

1. *Manner of observing.*—I have tried different scintillometres, all those indicated by Arago, and even a new one proposed by myself; but I have come definitively to the conclusion that for observing, none of them are equal to the naked eye.

It is easy, when one is a little accustomed to it, to judge with sufficient exactness whether one star scintillates more than another, and the scintillation may be indicated by a number, as in meteorology we mark by a number the state of the sky or the force of the wind. For my own use I have designated by 0 an absence of scintillation, and by 10 one of those strong scintillations which are seldom witnessed except when the star is near the horizon, when it appears to scintillate, change color, or even disappear. With a little practice, we succeed even in distinguishing degrees between the scintillations 0 and 1 and 1 and 2, &c.; we can then appreciate the scintillation with more exactness, and designate it, for instance, by 0.4, 1.6, &c. It is scarcely possible, however, to carry these subdivisions of gradation beyond the scintillations 4 or 5.

This is my own scale; another observer may frame such an one as he thinks suitable. The figures may vary, but the relations will remain essentially the same; thus my brother Marc, who has been engaged nearly a year in observing the scintillation, employs a much lower scale, yet we are generally in accord as to the relation of the numbers; we are always so in regard to the question whether one star scintillates more or less than another, and whether the scintillation during one evening is stronger or more feeble than during another evening. Now, this is the important point, for since all the observations cannot be made by the same person, it will be often difficult to know if the scintillation is exactly of the same intensity at Pulkova, at Archangel, on the Peak of Teneriffe, or at Morges.

I shall show presently, however, how these inconveniences can be obviated within certain limits. But in all cases, by following the mode of observation just indicated, it will be possible to know how at each of these stations the scintillation varies from one day to another, and whether this variation appears to bear a relation to any meteorological perturbation.

It is scarcely necessary to add that the height of the star which scintillates must always be known, or at least be capable of determination. But in place of observing this height directly, it is more simple to calculate it from the hour of the observation, and, to abridge the calculation, a table may be prepared in advance, indicating, with reference to the latitude of the station, the height of the stars observed at different sidereal hours. My own table gives these heights for Morges from half hour to half hour. This table answers the purpose, for in the interval of a half hour one may interpolate with all the necessary exactness, since it is useless to know the height of a star

within a few seconds; an approximation of a degree or half a degree suffices.

2. *Reduction of observations.*—It is well known that, all things besides being the same, the scintillation is so much the more feeble in proportion as the stars are nearer the zenith, whence it would seem impossible to compare observations if they have not been all made at the same height.

But, as I shall explain in a subsequent note, in comparing a great number of observations made under highly favorable conditions, inasmuch as there had been no apparent atmospheric perturbation, neither for some days preceding nor following, I have ascertained that the scintillation really decreases when the star aproaches the zenith, and that for any height whatever the scintillation is sensibly proportional to the product obtained by multiplying the thickness of the stratum of air which the luminous ray traverses by the astronomical refraction for the height under consideration.

Let us designate this product by P. By representing the height of the atmosphere by 1, and counting the refractions by sexagesimal seconds, we find that for different heights the values of P are:

Height of the star.	Value of P.	Height of the star.	Value of P.
20°	444	55°	49.7
25	286	60	38.7
30	198	65	30.0
35	143.1	70	22.5
40	106.9	75	16.1
45	81.8	80	10.4
40	63.6	85	5.1

These numbers sufficiently well represent the gradation of the normal scintillation at Morges, when the height of the star above the horizon varies from 20° to 75°. Below 20° the calculated values do not correspond with the observations, but the proximity of the horizon affords a sufficient explanation of this deviation, while as regards the stars situated at a greater height than 75°, their scintillation is in general so feeble, that the smallest error in the appreciation of it modifies very considerably the relation of the numbers.

In this way, when we have observed at a height of 60° a scintillation of 1.6, and would know the scintillation of the same star under the same conditions if it had been but at 45° above the horizon, we should have:

$$\text{Scintillation at } 45^\circ = \frac{1.6 \times 81.8}{38.7} = 3.4.$$

3. *Errors to be avoided.*—Often, from one day to another, the scintillation varies considerably, but it augments or diminishes in a proportional manner for all the stars, except perhaps for those which, near the horizon, have always a strong scintillation, and aside also from accidental causes which may momentarily modify it. Among these accidental causes we may cite first the crepusculum which almost always considerably augments the scintillation, and secondly the neighborhood of clouds. It was M. Kæmtz, I believe, who first observed that the scintillation is greater when there are clouds in the

sky, especially clouds chased by the wind. The fact is certain. I have recognized its truth in thousands of circumstances, and I am not aware of having detected a single exception. In view of this, I do not say that observations made on stars in the vicinity of clouds are to be rejected, for these observations may also have their importance, but it is necessary that regard should be had to this circumstance which sensibly modifies the results.

As the light of the moon interferes with observations, those made at full moon must necessarily be less exact than those made on moonless nights.

4. *Comparison of observations made by different persons.*—Here is the delicate point. What has been said may serve for the study of the phenomenon of scintillation when a single person is charged with making all the observations. But when there are several, how shall we know that the scintillation which one observer designates by 2.5 is equal to that which another designates by 2.5?

This uniformity I believe it impossible to realize; and, unless the observers were formed in the school of more experienced observers, I am certain that it is not to be attained. Yet I shall proceed to show that there is a mode of recognizing whether, in absolute value, the scintillation is stronger at one station than at another station.

At Morges, on nights of strong scintillation the stars in the zenith have a very distinct scintillation. During nights of average scintillation, the scintillation of stars at a very high elevation is weak, though always appreciable. But, on nights when scintillation is weak, the stars near the zenith have none at all. And the weaker the scintillation during an evening, the more extended is the spherical canopy of which the zenith is always the centre, and which comprehends the stars whose scintillation is inappreciable.

I have sometimes observed that at a time of very weak scintillation the stars ceased to scintillate when they had ascended 42° above the horizon, but I have never seen scintillation entirely cease in stars at a lower elevation; and yet, according to Arago, this sometimes happens. He cites, among others, the observations of M. de Humboldt, who says: On the banks of the Oronoco no scintillation can be distinguished in the stars, even at 4° to 5° above the horizon. Le Gentil asserted, that at Pondicherry, in the months of January and February, the stars have no scintillation. Beauchamp writes to Lalande that at Bagdad the stars, when they had ascended 45° above the horizon, no longer scintillated.

Garcin announced in 1743 that at Bender Abassi, on the shores of the Persian gulf, in spring, summer, and autumn, the stars showed no scintillation; it was in winter, only, that a slight one could be discovered. According to Humboldt, scintillation is, in general, not perceptible at Cumana when the stars are at an elevation of 25°, &c.

Assuredly, I have never witnessed at Morges, during six years, so weak a scintillation, but in thus discriminating the heights at which the stars cease to scintillate, the observations which I have made are susceptible of being compared with those of Le Gentil and Humboldt. Hence I particularly invite the attention of observers to this point,

as probably affording the best means of comparing the values obtained at different places on the globe.

While scintillation is readily appreciable for stars of the first magnitude, it is much less so for those of a lower grade; and thus in considering the stars as they become less and less brilliant, we arrive finally at those in regard to which scintillation is wholly unappreciable; though this limit itself varies from one day to another, according as the general scintillation is stronger or weaker. Here, then, we have still another criterion for a comparison of the scintillation. It suffices to say to what degree of magnitude the stars appear to scintillate; and as we have seen that the height of stars above the horizon has a great influence on the intensity of the phenomenon, it will be always necessary to cite by name some of these stars, and to indicate, besides, what is their height above the horizon, or at least the hour of the observation.

5. *Variable stars.*—Of all the stars which I have observed, alpha of Orion is that whose scintillation has appeared to me most irregular, but we know that the brightness of this star is not always the same. Now, in regard to the variable stars, we know at most but the duration of their period, and hence their scintillation is also an interesting phenomenon for our study. It would be interesting, especially in relation to η of the Ship, the singular variations in the brightness of which have so much surprised astronomers for 30 or 40 years past. Unluckily this star only begins to be visible at 31° of north latitude, and it is necessary to proceed nearly to the equator before it can attain an elevation of 30° above the horizon; that is, a height sufficiently great for the satisfactory study of its scintillation. This investigation must be resigned, therefore, to those who have an opportunity of observing the skies of the other hemisphere.

6. *Scintillation of planets.*—It is the general belief that the planets have no scintillation, or next to none. Yet Venus and Mars have often a very perceptible scintillation. In some rare instances I have even detected a slight scintillation in Jupiter and Saturn. It would be of some importance to those who seek to explain the phenomenon of scintillation to know whether, in fact, the scintillation of these planets is ever very distinct, and the inquiry may be properly recommended to those who may be placed in such physical circumstances as render the general scintillation unusually strong. Perhaps Jupiter and Saturn might then be seen to scintillate with great distinctness.

7. *Accidental observations.*—In order, finally, to complete the study of this phenomenon, it will be necessary not to neglect exceptional circumstances, among others the observation of scintillation in case of an aurora borealis, whether in regard to the stars which seem immersed in the light of the aurora or those situated in other regions of the firmament. During six years I have not been able to make, at Morges, any observation of this kind. As to observations of the scintillation by those stationed on mountain heights, M. Piazzi Smyth recollects that scintillation appeared very weak as observed from the summit of the Peak of Teneriffe, and I constantly realized the same

fact during my sojourn at the Great St. Bernard. Is it always the case?

8. *Accessory observations.*—That observations made upon the subject in question may be really valuable, it behooves us that they should be accompanied by meteorological observations as complete as possible. Let the indications of the barometer, the thermometer, and the hygrometer at least be noted, as well as the state of the sky and the force and direction of the wind. It is probable that in the localities where scintillation will be observed, meteorological observations will also be made and published; whence I presume it will not be devolving on observers any great increase of occupation if they be persuaded to combine the records which have been made for the study of meteorology with those collected for the study of scintillation.

There remain, doubtless, a number of other details, depending on the views of the observer and the circumstances in which he is placed—details which I omit because they will naturally vary with each individual. I am content with having indicated the principal subjects to which I would call the attention of observers, and whose importance has been disclosed to me by experience.

I may be allowed, in conclusion, to address to those who shall be disposed to observe the scintillation of the stars, particularly to those residing in any climate greatly differing from that of Morges, the earnest request that they will communicate to me a brief summary of their observations. That the results at which they arrive will be of the highest interest to me none can doubt, and the courtesy will be gladly reciprocated on my part by furnishing other details to such as may be induced to engage in these researches.

I may state, in addition to what has been said in the foregoing article on the subject of the planets, that I have seen Jupiter and Venus distinctly scintillate, the last particularly, on the 3d of January, 1841, when the weather was stormy and the barometer rapidly sinking. The feeble scintillation of the stars was, I remember, quite striking when I viewed them from the elevation of the Faulhorn.

I propose to give, in future numbers of the "Repertorium," various instructions for the observation of phenomena which are seldom the subject of investigation, such as the polarization of the light reflected by the atmosphere. In many phenomena this plays a more considerable part than is generally believed, and since, in observations upon Donati's comet, the assertion has been frequently made that its light was polarized, as was determined also by Arago with regard to the comets of 1819 and 1835, I take occasion to cite the following remarks of Brewster, which occur in the "Comptes Rendus" of the Academy of Sciences, XLVIII, 384: "I am not aware that those who have observed traces of polarization in the light of comets have noticed the direction of the plane in which it was polarized. Without such an observation, however, we cannot discover the cause. If the light is polarized in a plane passing by the sun, the comet, and the eye, we must infer that it is polarized by the *reflection* of the light coming

from the sun; if it is polarized in an opposite plane, the polarization may be due to the *refraction* of the atmosphere. If it is polarized *quaqua versus*, (on every side,) that may depend on three causes, viz: on the refraction by the surfaces of the object and eye-glasses; or on an imperfection in the annealing of the glass of which the lenses are formed; or on the circumstance that one or more of the lenses are compressed by the mountings. Supposing it to be an effect of the first of these causes, the openings of the object and of the eye-glasses should be reduced to a central band, which would eliminate the light polarized in an opposite plane, and would leave that which is polarized in a plane perpendicular to the direction. By turning the tube or the lenses the direction of the polarization would be changed. If the polarization is produced by a defect in the manufacture of the glass of the lenses, the existence of such imperfection will be rendered evident by exposing the lenses to the polarized light. If the observed polarization is owing to the reflection of the rays of the sun by the comet or its envelopes, the small stars will be seen more distinctly through it when the polarized light has been extinguished by one of Nicol's prisms."

L. F. KÄMTZ,
Editor of the "Repertorium."

SYNTHETICAL STUDIES AND EXPERIMENTS ON METAMORPHISM

AND ON THE FORMATION OF CRYSTALLINE ROCKS.*

By M. DAUBRÉE.

TRANSLATED BY T. EGLESTON, FOR THE SMITHSONIAN INSTITUTION.

INTRODUCTION.

In varietate unitas (LEIBNITZ)

ONE of the first and most important problems which geology has been called upon to solve is to determine what, in the formation of the solid crust of the globe, is the part to be assigned to aqueous and that which ought to be attributed to igneous action. The question, although it has been a long time under discussion, has not yet been definitely settled ; it has even been complicated, since, in studying more rigorously the different strata, there have everywhere been found those which unmistakably exhibit evidence of a double origin. Was it at the time of their formation that these ambiguous strata acquired their double characteristics, or was one of these characteristics acquired after the other, and, in the latter case, how can such a succession of effects be accounted for ? Such are the subjects, the study of which constitutes, in its greatest generality, that part of geology which has been called *metamorphism.*

When the influences which the interior regions of the globe exercise on the surface show themselves by daily phenomena, such as hot springs, eruptions of volcanoes, earthquakes, or by effects of which man has not been the witness, but of which he finds stupendous traces, such as the eruption of rocks and the upheaving of mountain chains, it is a subject full of interest, and in which every one is ready to engage. But when these influences have produced only slow modifications invisible, inaccessible to direct observation from the depth at which they have taken place, and are without doubt still going on, it is easily conceived that they excite incomparably less interest, and, moreover, that they present peculiar difficulties of investigation. If, however, we consider that these great transformations were carried on over a large part of the earth's crust, and that, according to all probability, their importance increases from the

* Annales des Mines. 5 series, vol. 16, pp. 155 and 393.

surface downwards to the point where they become predominant in the depths ; that, in fine, they are in intimate connexion with all the other manifestations of the internal activity of the globe, it must be admitted that their study well merits the most serious attention.

It is this study of a phenomenon, so far as it is possible for us to understand it at this day, that I present in this work. I shall divide it into three parts : the first will be devoted to the history of the question ; the second to the exposition of those facts which can be considered as certain, and which the theoretical explanations which form the subject of the third part, ought to explain.

I have given considerable development to the historical part. To signalize the efforts by which the theoretical ideas which we now possess have been gradually acquired, is not only to render a just homage to those who have illuminated science by their works, but also to present a salutary warning against illusive speculations. Impulses of the imagination in the domain of geology are so much the more to be deprecated, as even the induction founded upon observation is here most frequently without means of verification.

Although the historical citations are numerous, there are still many gaps ; but not to too much extend this sketch, I should say that I restrict myself to works of a fundamental character.

PART FIRST.

HISTORY.

CHAPTER I.

STATE OF GEOLOGY AT THE APPEARANCE OF THE HUTTONIAN SYSTEM.

During the last two centuries there have been men who, without being what we now call geologists, have advanced such remarkable ideas concerning the system of the globe, that they have had an incontestable influence on the works of those who, since their time, have specially studied this part of science. Thus Descartes considered the earth as a sun cooled on its surface, preserving in its interior a *central fire*, which was the cause of the return of the waters of infiltration towards the surface, of the presence of metals in veins, and of the dislocations of the solid crust.*

From the same hypothesis of an original fluidity, Newton deduced

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* *The Principles of Philosophy* of Descartes first appeared in 1644, (Latin edition of Amsterdam.) The acute genius of Descartes divined, as it were, several general facts, which observation has since then established.

"Feignons que cette terre a été autrefois un astre—en sorte qu'elle ne différait en rien du soleil, sinon qu'elle etait plus petite. Au-dessus de la croûte intérieure fort pesante, de laquelle viennent tous les métaux, est une autre croûte de terre moins massive qui est composée de pierres, d'argile, de sable et de limon. Ce n'est pas le seul argent-vif qui peut amener soit les métaux de la terre intérieure à l'extérieur les esprits et les *exhalaisons* font le semblable aux regards de quelques-uns, comme le cuivre, le fer et l'antimoine."—(French edition of 1668, IV part, §§2, 44 and 72.)

by calculation the flattening which the terrestrial spheroid* should present, and this idea was also adopted by Halley.

Still later, Leibnitz, stimulated both by the ideas of Descartes and the very judicious observations of Stenon, published a work which, notwithstanding the inevitable paucity of the facts on which it was founded, bears the stamp of the genius which conceived it.† It was, without doubt, from this source that the illustrious author of *Les Epoques de la Nature* drew his most profound inspirations;‡ but the works of Buffon, although exciting the attention in the highest degree, were not calculated to convince, but to strike the imagination very forcibly, and thus provoked precise observations destined to solve the doubts which they had raised.‖

It was not in reality until the end of the last century, at the same epoch when there was opened up for chemistry so new an horizon by the discoveries of Lavoisier, Schûle, Priestley, and Cavendish, that the history of the globe began to disengage itself from preconceived opinions, and that observation began to take the place therein which belonged to it. The exact facts which men endowed with a genius for observation, such as Agricola, Bernard de Palissy, and Stenon had before signalized, were merged in an ocean of hypothesis. The ideas concerning the history of the earth, published by Linnæus, the rival of Buffon, as historian of nature, presented only a summary of the facts known and the ideas in vogue at that period.§

De Saussure,¶ Pallas,** and Werner inaugurated, by works nearly contemporaneous, the era of *positive geology*, and all these disapproving emphatically of the boldness of Buffon, opposed his ideas, even those which were well founded.†† Of these savants, all eminent observers, the two first were sparing of their inductions. But Werner went further : he tried to analyze, to classify, and to co-ordinate facts, and to describe them in definite and precise language, and gave to the science the name of *geognosy* in contradistinction to geology,

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**Principia Mathematica Philosophiæ Naturalis*, 1667.

†Leibnitz gave a sketch of the dissertation, known under the name of *Protogæa*, in the *Acta Eruditorum*, in the month of January, 1693 ; but it was not until thirty-three years after his death, in 1749, the very year that Buffon published the first three volumes of *Natural History*, that the whole *Protogæa* was published.

‡*La Theorie de la Terre* is dated 1749. *Les Epoques de la Nature* appeared nearly thirty years later, in 1778. Before Buffon, Mairan, having a special object in view, had developed the idea of a central heat.

‖The influence which Buffon exercised over the progress of geology has been deservedly acknowledged by Mr. Elie de Beaumont.—(*Leçons de Géologie Pratique*, p. 24.)

§*Systema Naturæ*, 1775.

¶De Saussure was born in 1740. He commenced his travels in 1760, and published in 1779 the first volumes of his *Voyage dans les Alpes*, where he has recorded so many important facts which have served, as it were, for the foundations of geology.

**Pallas published in 1777 his observations on mountains, and a few years after the narrative of his long travels.

††These three great observers believed, as did Linnæus, that the strata were formed by aqueous action, and that the volcanic phenomena were simply local accidents. De Saussure declared, in 1798, after having visited Auvergne, that he could not admit that basalt was of igneous origin, much less could he admit this origin for granite.

which up to that time had been little else than an assemblage of conjectures.*

To go back to the doctrines which were in vogue at the time when the idea of metamorphism appeared, we ought first to call to mind the fundamental principles of the celebrated professor of Freyberg, especially those which have disappeared in the progress of subsequent discoveries. According to Werner, granite and the other crystalline rocks are marine deposits, as much so as the stratified and fossiliferous rocks. At a remote period the different materials from which the strata were derived were either dissolved or held in solution in the ocean. It was from this *chaotic* ocean that all the strata were, one after the other, precipitated, some by chemical and others by mechanical means. This later mode of formation distinguished the crystalline from the sedimentary rocks. According to this system, granite, which composes the highest peaks of the globe, and which also supports the regularly stratified deposits, was formed first, together with gneiss and the crystalline schistose rocks which are associated with it. As no organic remains are ever found in them, the formation of these deposits necessarily preceded the existence of animals and vegetables, whence they received the name of primitive; afterward the sea became shallower, and sank away into the interior cavities of the earth.† During this second period a chemical precipitation of the silicates continued to take place, but at the same time mechanical deposits began to be formed. By this double process, at once chemical and mechanical, the intermediate or deposits of *transition* which contain crystalline associated with sedimentary fossiliferous rocks were formed. During a new period of the decrease of the waters the *secondary* strata were deposited, the highest mountains of which, it was then thought, never reached the altitude of the peaks of the older deposits. They are often in horizontal beds and abound in organic remains. During their consolidation, the strata experienced ruptures from which resulted cavities of all dimensions. The water, in leaving these cavities, incrusted the long fissures, through which it flowed, with the different materials it held in solution, and thus gave rise to *metallic veins*. Such, according to Werner, is the origin of all the strata composing the crust of the globe, not including, however, the alluviums, the vegetable earth, and the products of volcanic fire, which he attributed to the conflagrations of the beds of carbonaceous combustibles. He explained the intimate relation which evidently exists between the primitive and secondary deposits, both in their mineralogical relations and in their association, by supposing that the composition of the ocean, and consequently the nature of its deposits, have varied from the time when granite was precipitated from it, sometimes by a gradual and sometimes by a

*By the aid of positive facts, which Füchsel had previously, in part, described in 1762, Werner proved that a kind of chronology of the physical events which had contributed to the formation of the globe could be established.

†Leibnitz had already tried to explain the drying up of continents by the retreat of the water into vast interior voids, which he attributed to ancient cavities of gaseous inflation produced at the time of the primitive fusion.

sudden process*. In short, according to the system of Werner, all the strata were produced at their origin as they now exist. The internal activity of the globe is completely disregarded as well in respect to the formation of crystalline rocks and metalliferous deposits, as to its being the cause of the dislocations undergone by the stratified deposits of all ages.

CHAPTER II.

HUTTONIAN SYSTEM.

While the teachings of Werner began to captivate general attention and excite the enthusiasm of his pupils, thanks to the graces of speech of the master and to the power of the method with which the facts then known were brought together, another and a very different doctrine arose in Scotland. Gifted with a genius for observation not less eminent than the professor of Freyberg, James Hutton came to opposite conclusions on certain fundamental phenomena, and these two antagonistic schools were simultaneously established. As far back as 1785 Hutton published his *Theory of the Earth.*† Ten years later, after having made several journeys in Scotland to collect new observations, he developed his ideas in a more voluminous work under the same title. But what contributed more than anything else to make Hutton's doctrine known was the work of John Playfair,‡ his disciple and friend, who was at the same time a mathematician, a geologist, and a distinguished writer. His talent of exposition and elegance of style vigorously sustained the new ideas, as well against the violent attacks of a small number who accorded to them a serious consideration, as against the disdainful indifference of the majority, who regarded them as unfounded. The importance of the works of Hutton and of Playfair, in which, for the first time, we find certain fundamental ideas of modern geology established and developed, and in particular the principle of metamorphism, obliges me to give here their leading propositions, as I have done for those of Werner. This is, in

* When the solution covered the whole of the globe, and was of great depth, it was tranquil and pure. For this reason the first rocks were exclusively crystalline. Afterwards, when the level of the sea was lowered and the earth appeared above it, currents exercised a greater influence and destroyed a part of the pre-existing masses. On the other hand, atmospheric agencies attacked the emerged rocks. It is thus that mechanical deposits were formed, and even became abundant.

† *Theory of the Earth, or an Investig.tion of the Laws Observable in the Composition, Dissolution, and Restoration of Land upon the Globe;* by James Hutton, M D., F.R.S. Read the 7th of March and the 4th of April, 1785, before the Royal Society of Edinburg; 96 pages, in 4to. A second paper on the same subject appeared in 1786. The second edition of the work is entitled, *Theory of the Earth, with Proofs and Illustrations. In four parts.* Edinburg, 2 vols., in 8vo., 1795.

On the other hand, Werner published his *Treatise on the Characters of Minerals*, in 1774, at the age of twenty-four years. Soon after, about 1780, he began to develope in his lectures the principles of *Geognosy*. His *Classification and Description of Strata* dates 1787, and his *New Theory of the Formation of Veins* in 1791.

‡ Playfair's *Illustrations of the Huttonian Theory of the Earth.* Edinburg, 1802.

reality, the only way to do justice to the author of these fundamental discoveries and to his successors. We shall follow the order adopted by Hutton and his commentator.

The author remarks in the outset that certain deposits, which he qualifies as primitive, appear to have been formed in the same manner as the recent sedimentary strata. It is thus that the beds of the Alps, considered as primitive, cannot be anterior to the existence of vegetables, since they contain numerous remains of them in the form of mineral combustibles. Furthermore, other crystalline deposits contain beds consisting of sand and pebbles; they were, therefore, formed from the detritus of pre-existing deposits; for if we should admit, with Deluc, that quartz sand is a chemical deposit, we cannot explain why there is none existing in the midst of the most crystalline masses, particularly in granite and metalliferous veins. The compactness of these rocks, which are at the same time sedimentary and crystalline in structure, could only result from the action of heat and from softening. According to Hutton, if a foreign substance in a state of solution had penetrated the pores of the rock, the liquid would have of necessity left certain cavities. The masses of lamellar limestone which often accompany this species of crystalline rock also supply him with an argument; for he assumes, *as beyond a doubt*, that limestone, in which Black had just discovered carbonic acid, could only retain its gaseous element at a high heat when the rock was at the same time submitted to great pressure. He adds that, under these circumstances, carbonate of lime can even be melted. We know that this bold conjecture was afterwards confirmed by the experiments of his most celebrated disciple.*

The mode of occurrence of the different species of mineral combustibles contributed to the support of this same theoretical idea. After having remarked that, in the Isle of Sky, ordinary lignite changes, under the basalt which covers it, into a compact combustible, with a brilliant fracture like coal, Hutton concluded, as Buffon had previously supposed, that coal had the same origin as lignite; that the beds of coal and deposits of bitumen result from the transformation of vegetable and mineral matter by heat and under the influence of pressure.

In the generalization of this idea, he came even to include graphite in the series of products derived from the burial and transformation of organic bodies. Thus, by an idea entirely new, the illustrious Scotch geologist supposed water and the internal heat of the globe to have successively co-operated in the formation of the same rocks.

It is a characteristic of genius to comprise, under a common origin, very dissimilar phenomena. Subterraneous heat, according to Hutton, not only consolidated and mineralized the strata at the bottom of the sea, but it had, moreover, raised and depressed beds which were originally horizontal. Saüssure had then just observed the elevation

* Sir James Hall, whose conclusions on the simultaneous action of heat and pressure will be noticed presently.

and subsequent depression of the celebrated conglomerates of Valorsine, without, however, giving an opinion as to the cause of the phenomenon.* Another discovery, due also to Hutton, had an important influence on geology; I refer to the eruptive origin of granite. In the study of this rock in his own country, especially at Portsoy and in Glen-Tilt, he perceived that it forms veins in the surrounding masses, showing that it was injected in a fluid state; and, further, that its mineralogical nature indicated the action of heat. It is, however, just to add that Strange, a compatriot of Hutton, had just come to the same conclusion.† The rocks known to the English under the names of *trap*, *toadstone*, and *whinstone*, have also been injected in regions where there were no indications of volcanoes.‡ Hutton proves this by the numerous examples which he had observed in Scotland, a country eminently favorable for this kind of study. He investigated, besides, the cause of the difference between *these subterranean lavas* and those thrown out from volcanoes, in which neither zeolites nor calc spar are found. Here, too, it is heat under pressure, which appears to him to explain this difference.‖ To the author of these fundamental deductions, metallic veins, as Descartes had previously suspected, could only be injections of melted masses.

In short, Hutton explained the history of the globe with as much simplicity as grandeur. The atmosphere is the region where the rocks decompose; their detritus next accumulates at the bottom of the sea. In this great laboratory the shifting material, under the double action of the pressure of the ocean and of heat, is mineralized, and transformed into crystalline, having the appearance of the primitive rocks, which are afterwards to be raised by the action of this same internal heat, and again demolished in their turn. The disintegration of one part of the globe serves, therefore, for the continual reconstruction of other parts, and the continuous destruction of the inferior deposits produces, without cessation, rocks in a state of fusion, to be injected in turn through the sedimentary deposits. It is a system of destruction and of reconstruction of which it is impossible to conjecture either the commencement or the end. As in the planetary motions, where the perturbations correct themselves, we see continual changes, though restrained within certain limits, of such a character that the globe shows no signs either of infancy or of old age.

* The observations of Stenon on the same subject, which Elie de Beaumont has brought to light, (*Annales des Sciences Naturelles, vol.* xxv, p. 137 to 183,) appear to have been entirely forgotten at that time.

† *Transactions*, vol. lxv, p. 5, 1775.

‡ We must, however, remember that Desmarets had already long ago proved the igneous origin of the basalt of Auvergne, of Italy, and of the northern coast of Ireland, (1768–1771.)

‖ Speaking of the very conceivable error which Hutton committed on the origin of these calcareous infiltrations, I cannot help remarking with what penetration Spallanzani, another great observer of nature of the same period, recognized the mixed origin of the amygdaloid rocks of the Euganæan Hills. The disposition of their cavities satisfied him that the rock had been melted, at the same time that the presence of carbonate of lime in ttoresult from infiltrations.

In considering this action as a *continuous* phenomenon, Hutton obscured his beautiful conception, but he rendered an immense service in showing that natural agencies which operate under our eyes ought to serve as a sufficient explanation of the history of the globe, and that we need not have recourse to other means of action than those which nature now uses, while all the other systems, on the contrary, suppose occurences which have no analogy with what now takes place. Thus Hutton is really the founder of the prolific principle of the transformation of sedimentary rocks under the action of heat.

However, we shall see, further on, that there are a great many exceptions to be made to such absolute conclusions.* Like most men of genius who have opened new paths, Hutton, it must be admitted, exaggerated the range of the ideas which he originated. We cannot, however, reflect without admiration on the profound penetration and the rigor of induction of this clear-sighted man, who, at a period when there were very few precise observations, was the first to recognize the simultaneous action of water and heat† in the formation of the strata, and imagined a system which embraces the entire physical history of the globe. He laid down principles which are now universally admitted, at least so far as they are fundamental.‡

CHAPTER III.

SUCCESSORS OF HUTTON.

Even before the publication of Hutton's doctrine an Italian observer brought to light a fact from which he inferred that recent igneous action may transform sedimentary rocks, even such as are most modern. As early as 1779 Arduino‖ announced in the clearest

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* Iron pyrites, so abundantly distributed, as well as all the minerals of veins, appeared to him to be the productions of the dry way ; it served him as a proof of the action of heat which the strata had undergone. He extended this observation to the flints of the chalk, the solidity of which contrasts with the physical state of the silica known in laboratories.

† In the cosmologies of Leibnitz and Buffon the central fire is supposed to have acted only at the origin of the globe, before the formation of deposits. Combating certain ideas which were in vogue, Hutton clearly shows that the internal heat of the earth can exist without any interior inflammation or combustion.

‡ Hutton, born in 1726, made observations in the wildest parts of Scotland, and meditated more than forty years before publishing his first sketch. The sight of the veins of granite of the valley of Glen-Tilt struck him as with a ray of light. He himself discovered a larger part of the facts upon which he based his theories.

‖ *Osservazioni Chimiche sopra Alcuni Fossili* ; Venice, 1779. After having been employed at the mine of Montieri, in the Maremme of Sienna, Arduino went to live at Vicenza, where he was a surveyor. (Letters of Fortis on Vicentin.) Pazini has noticed his work in the *Bulletin of the Geological Society of France*, vol. iv, p. 112.

"It appears to me," says Arduino, "that magnesia is only lime, possessed of peculiar properties consequent upon subterraneous igneous action." "I have only found it in the great ruptures of the calcareous beds of our mountains."

It is extremely remarkable that this new and bold assertion was made during the very year that magnesia was discovered by the experiment of Retzius and Bergmann to be an earth distinct from lime. It was not until eleven years later, in 1791, that Dolomieu called attention to a peculiar kind of magnesian limestone which he had noticed in Southern Tyrol.—(*Journal de Physique*, vol. xxxix, p. 3.) The next year Theodore de Saussure published the analysis of this rock, and gave it the name of *dolomite*, which it has still preserved.—(*Journal de Physique*, vol. xl, p. 161.)

manner the idea that the dolomites of Lavina, in the Vicentine, had been formed at the expense of secondary limestone. The brechiform nature of the rock caused him to think that the limestone had been broken, and that the modifying and igneous agent had afterward penetrated from below, through the fissures. Twenty years later an English geologist, Dr. G. Thomson,* after having examined the blocks of crystalline limestone from Mt. Somma, so rich in various minerals, was led to consider them as Apennine limestone which had been modified by heat, and propounded the question whether the marble of Carrara had not had the same origin.

But what at that time contributed most of all to the support of the newly-established principle of the transformation of rocks was a series of experiments made by Sir James Hall.† They were suggested, he says, as far back as 1790 by Hutton. This was, properly speaking, the first time that any one had seriously tried to introduce experimental synthesis in the study of geological phenomena by bringing to bear upon it something else than the observation of facts, as nature presents them, and chemical analysis. Hall was encouraged in this research by the frequent presence of nodules of crystalline limestone in trap. He proved that under a definite pressure carbonate of lime can at a high heat retain its carbonic acid, and that the combined effect of heat and pressure is to agglutinate this substance into a solid mass, which is sometimes crystalline.

He perceived also that wood under the same conditions changed into a kind of lignite. Although this was the demonstration of a fact very simple in appearance, Hall devoted not less than three years to his experiments, which were more than one hundred and fifty in number; this gives an idea of the difficulties to be encountered in operating with heat under high pressures.‡

Perhaps no country presents more beautiful and more numerous examples of the intercalation of eruptive rocks than certain regions of Scotland. It is naturally in a country broken up in this way that the first notions of this kind of phenomenon should be obtained. The important memoirs also, published by Macculock,‖ which will hereafter be classic, furnished new arguments for the support of the theory with which the same country had inspired Hutton. It may well surprise us that ideas for the most part profoundly correct, and supported at the time by many precise observations, should have remained so long disregarded or perhaps unknown on the continent. Even at Edinburg, Jameson, an ardent disciple of Werner, controverted doctrines which might be called Scotch with arguments bor-

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* On the nature of the marbles thrown out from Vesuvius and on the possible extent of volcanic influences.—*Bibliothèque Britannique*, vol. vii, p. 40, 1798 Brieslach adopted and defended this opinion.

† Account of a series of experiments showing the effects of compression in modifying the action of heat. Read June 3, 1805.—*Edinburg Philosophical Transactions*, vol. vi, 1812.

‡ Bucholz has announced that crystalline carbonate of lime can be obtained by calcination under ordinary pressure.

‖ *Description of the Western Islands of Scotland*, 3 vols., 1819.

According to Macculock, amphibolic schists appear to result from the decomposition of clays.

owed directly from the school of Freyberg. In France, Dolomieu, Giraud-Soulavie, Faujas-Saint-Fond, who since the end of the last century earnestly combatted the hypothesis of Werner on the aqueous origin of basalt, and d'Aubuisson, whom the study of Auvergne obliged a little later to adopt an opinion opposed to that of his master, gave but little attention to ideas towards which it would seem they ought to have felt themselves strongly attracted. Cuvier, in the report on the progress of natural science since 1789, which was published in 1808, only cites Hutton to speak with great doubt of the opinion of this savant on the intervention of heat in the origin of basalt.* "How," asks Cuvier, "are we to resolve the problems of the history of the globe with the forces of nature which we know to be at present in existence?"†

It is, in reality, only since 1815, after the relations of Great Britain with the continent were renewed, that the labors of Hutton and his disciples began to be known to the rest of Europe; it was then only that there appeared in Paris a translation of the works of Playfair, which had been published thirteen years before in Edinburg.

A few years after, Dr. Boué,‡ who had studied geology in the Scotch capital, and who had explored Scotland, contributed to propagate these ideas. Moreover, establishing himself on the modifications observed in the neighborhood of the plutonic rocks of the Isle of Sky, at Monzoni and elsewhere, he put forth the idea that gneiss and other crystalline rocks contiguous to the granite are only sedimentary strata transformed by ancient eruptions of that rock. Doubtless this was greatly to exaggerate the extent and power of the phenomenon; certain geologists, however, have retained this theory to the present time.‖ After having visited Scotland, Mr. Necker also became an interpreter of the principal views of Hutton.§

Sir Charles Lyell did his part, by elegantly written works, to make known the Scotch doctrine. As early as 1825 he summed up, under

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*Edition in 8vo, p. 171–2.

† Report before cited, p. 180. This last phrase is a criticism of the other principle which Hutton tried to establish, that ancient phenomena appeared to be due to the action of actual causes sufficiently prolonged.

"This progression is too slow to be immediately perceived by man; the most remote fact that experience can furnish ought to be considered as the momentary *increment* of an immense progression, which has no other limits than the duration of the world. Time takes upon itself the function of integrating the parts of which this progression is composed."—*Playfair.* Dolomieu was entirely opposed to this opinion.

"It is not time, but force that I invoke. Nature demands of time the means of repairing disorder, but it receives from motion the power of overthrowing."—(*Journal de Physique*, vol. ii, 1792.)

‡ Tableau de l'Allemagne, *Journal de Physique*, 1822, Mémoire Géologique sur le sud-ouest de la France. (*Annales des Sciences Naturelles*, vol. ii, p. 387, 1824.) Mr. Boué tried to show the eruptive origin of granite, of porphyry, and of grunstein in the different parts of Germany. He based his principal conclusion on the excellent observations of Palassou in the Pyrenees. The beds of iron in the environs of Vicdessos appeared to him to have been formed by sublimation.

‖ Thus, according to Leopold de Buch, all the gneiss of Finland is only the result of the tranformation of argillaceous schists, under the action of substances which were disengaged at the time of the upheaval of the granite; this is, he adds, the opinion adopted by all geologists.—(*Ueber granite und gneiss. Abhandlungen der Akadamie der Wissenschaften zu Berlin*, p. 63, 1842.)

§ *Voyage en Ecosse et aux iles Hebridés*, 1821.

the name of metamorphism, the changes which, according to the theory of Hutton, the rocks of sedimentary origin have undergone by the action of central heat: this is the name that since then has been adopted.*

But, at this epoch, what excited attention in the highest degree was the work of Leopold de Buch, on the geology of the southern Tyrol, published in 1822,† Already in the last century, as we have before said, Arduino had attributed the origin of the dolomite of Vicentine to a transformation of limestone. Twenty years after, Heim, a German geologist, whose works contain a great number of facts which were then new and judiciously observed, made observations in Thuringia which led him to the same conclusion.‡

Leopold de Buch presented this hypothesis anew in a striking manner, while giving it a wider scope. For him the colossal and ruptured masses of dolomite in the valley of Fassa are only limestones, into whose innumerable fissures the eruptions of melaphyre, which raised and broke them up, have introduced magnesia in a state of vapor. He was thus brought to the conclusion that it is not heat alone, but also chemical emanations which have had an influence in the transformation of rocks.|| This was, moreover, increasing the importance of mechanical dislocations by showing how they might open sources of sublimations or vapors, which afterwards act upon the rocks. It was, in a word, a new point of view introduced into the science by one who was then already at the head of geologists.

Later research has shown that certain modifications must be applied to this conclusion; but the questions which the bold hypothesis of the metamorphism of dolomite gave rise to elicited investigations which have enriched science. An idea which leads to discoveries rests, in general, on some profound relation and denotes an inventive mind.

The Alps, which will ever be a classic region for geology, as much on account of the energies which produced this chain as of the deep and imposing rents through which it exposes its internal construction, have furnished, together with Scotland, the fundamental observations for the theory of metamorphism.

Previously, in a memoir which marks an epoch in science, and which appeared at the time that Cuvier and Brongniart published

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*Metamorphic rocks form a part of his *hypogene rocks*.

†Lettres sur la Geologie de Tyrol méridional.—(*Annales de Chimie et de Physique*, vol. xiii, 1822. *Taschenbuch*, vol. xix and xx, 1824.)

‡Speaking of the cavernous dolomites of the Zechstein, he says that the same kind of dolomite is found in the Muschelkalk; that it is only a peculiarity of limestone. It was not known at this time that this rock contained magnesia. This modification of limestone, he adds, is in relation with the accidents which have been produced from below upwards, and, among natural forces, vapors are the only ones which could have produced such an action; they have at the same time formed gypsum, which is always associated with the dolomite.—Heim, *Geologische Beschreibung des Thuringerwaldgebirgs*, 1806.

||However, before this time Breislach, in his excellent description of the Solfatara of Puzzuoli, had shown that vapors alter rocks. Cordier, in 1820, had also shown that alunite results in general from the action of sulphurous vapors on feldspathic rocks.—(*Annales des Mines*, 1st series, vol. v, p. 303.)

l'Essai de la géographie minèrologique de environs de Paris, Brochant* had signalized, in the most precise manner, the passage of sedimentary to crystalline rocks, then reputed primitive in the Alps of the Tarentaise. Still later he had the good fortune even to find fossils in them. Applying to these crystalline rocks nearly the same arguments which Hutton had used, he concluded that the granular, micaceous and talcose limestones, the micaceous, talcose and amphibolic schists of this region of the Alps, were of sedimentary origin, and he referred them to the formations of transition, on account of their analogy to those of Germany. He even went so far as to bring together in the same group the granitic rocks of Mont Blanc and the talcose and feldspathic rocks with which they are associated, and believed he could establish the relatively recent age of these supposed alpine granites. Without adopting the principle of the transformation of rocks, he, nevertheless, contributed, perhaps without knowing it, and with a remarkable clearness and rigor of deduction, to the development of these new ideas.†

An excursion into the Alps of Glaris, made by Studer and Mérian in 1826, revealed for the first time a passage of the secondary fomations (flysch) to rocks as crystalline, as the micaschist and gneiss of St. Sothard and Chamouny.‡ As said Elie de Beaumont,|| in a letter that he wrote twelve years later, after having visited the same localities, "We have before our eyes one of the most evident facts of metamorphism in the Alps, and at the same time one of those which best prove that these phenomena are not exclusively confined to the oldest formations."

Such is, moreover, the important conclusion to which Elie de Beaumont had on his own part arrived, nearly at the same time with Studer, in a careful examination of the Alps of Daupheny and Savoy, an examination which was of immeasurable importance for geology. He recognized in the graphite of the Col du Chardonnet, which is associated with feldspathic rocks, a result of the transformation of anthracite,§ and after a mature consideration he proposed to refer the age of a part of these crystalline rocks to the jurassic formation.

Thus the prestige of antiquity belonging to the formations of the Alps, which had already been shaken by Brochant and Leopold de Buch, was forever overthrown; and at the same time Elie de

*Geological observations on the formations of transition of the Tarentaise and other parts of the chain of the Alps.—(*Annales des Mines*, 1st series, vol. xxiii, p. 321; 1808.)

Considerations on the place that the granitic rocks of Mont Blanc should occupy in the order of primitive rocks.—(*Annales des Mines*, 1st series, vol. iv; 1816.)

Discovery of organic fossils in the crystalline rocks.—(*Annales des Mines*, 1st series, vol. iv; 1819.)

†Attention was again attracted to the beds which compose the chain of the Alps by the work of Blackwell.—(*Travels in the Alpine parts of Switzerland and Savoy*; 1822.)

‡Zeitschrift von *Leonhard*, vol. xxv, p. 1; 1827.

||Letter from Elie de Beaumont to Studer, cited in *Leonhard's Jahrbuch*, p. 352; 1840.

§On the occurrence of vegetable fossils and graphite at the Col de Chardonnet, department of the Haut Alps.—(*Annales des Sciences Naturelles*, vol. xv; 1828.)

Beaumont made known how recent is the elevation of the greatest chain of mountains in Europe. These results, at the same time so novel and so grand, deeply impressed all minds, and gave an extraordinary impulse to geological studies.

Appointed at this time to the chair of geology at the School of Mines, Elie de Beaumont thenceforth powerfully contributed to spread the geological doctrines on which he had conferred so many acquisitions, especially through observations made by himself in the Alps, or derived from the memoirs of Maccullock on Scotland. The comparison by which he summed up the gradual transition of sedimentary to crystalline rocks, likening it to "the physical structure of a brand half burned, in which we can trace the ligneous fibres far beyond those points which still preserve the natural characters of wood," is as clear as it is profound.* He showed, besides, that limestones and other rocks might have crystallized without having been fused, just as occurs with a bar of iron long heated below its point of softening.†

When Elie de Beaumont, discovered a few years after, in the midst of l'Oisans ‡ granitic rocks jutting out above the jurassic limestone which had become saccharoidal, and in contact with which they have produced little veins of metallic minerals, while it modelled itself exactly to the undulated contours of the surface, he still more enlarged the field of metamorphic phenomena.

Facts exactly like those which had just been discovered in the Alps were recognized in the region of the Apennines. The marble of Carara, and the mass of talcose and micaceous schist which accompany it, were, by the observations of Pasini, Pareto, Guidoni, and Paul Savi,‖ which were confirmed by Hoffman,§ classed in the secondary jurassic or cretaceous formations. Tuscany had furnished to Savi, as far back as 1829, many remarkable examples of various alterations in the neighborhood of serpentine. The Pyrenees also revealed at the same epoch facts which confirmed and extended these new ideas.

In 1819 Palassou, an observer as judicious as modest, after having for four years explored these mountains, announced with certainty that no primitive limestones existed in this chain, and that beds of limestone as crystalline as the marble of Paros alternated with fossiliferous beds, and sometimes even contained them.¶

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* *Annales des Sciences Naturelles*, vol. xv; p. 362–372.

† *Annales des Mines*, 3d series, vol. v, p. 61.

‡ Faits pour servir à l'histoire des Montagnes de l'Oisans.—(*Annales des Mines*, 3d series, vol. v, p. 1.)

‖ The works of these geologists have been reviewed by M. Boué in the *Bulletin de la Societé Geologique de France*, vol. iii, p. 42.

§ Entdechkungen über den Marmor von Carrara.—*Jahrbuch*, p. 102, 1833. Gebirgs Verhältnisse der Grafschaft Carrara.—*Jahrbuch*, p. 563, 1834. *Karsten's Archiv*, vol. 6, p. 229. We ought here to call to mind that M. de Blainville had at this time previously discovered in the polished specimens of this last rock unequivocal vestiges of polypiers.

¶ Memoir on the limestones of the Pyrenees.—(*Suites des Mémoires de Palassou.* Pau, 1819.) De Charpentier had also noticed like alterations in his important work on the Pyrenees, 1823.

Dufrenoy showed that these transformations were due to the intercalation of granitic masses; that they existed throughout the entire extent of the chain, and that they affected formations of different ages, up to and comprising the chalk.* He afterwards showed that accumulations of iron ore in the neighborhood of granite also took place after the formation of the chalk and in consequence of the upheaval of that chain.† Thus the formation of metamorphic rocks and of metalliferous deposits attested the power of the action of granite. Besides this, Dufrenoy also found in the cretaceous formation the traces of peculiar alterations due to the proximity of ophites.‡

Among the first observers of metamorphic phenomena it is just to mention M. Keilhau, who in 1826 discovered that the deposit of transition in the environs of Christiana is generally modified near granite; § and also Dr. Charles Jackson, who in 1827 announced that amygdaloidal rocks were produced by the action of trap rocks on the sandstone in Nova Scotia.

CHAPTER IV.

WORKS RELATING TO OTHER EFFECTS WHICH THE INTERIOR OF THE EARTH EXERTS OVER THE EXTERIOR CRUST, AND WHICH ARE RELATED TO METAMORPHISM.

Besides the effects of transformation of which we have just spoken, there are various other phenomena which appear also to result from the action which the interior of our planet has exercised in ancient times, or still exercises, upon the external crust; such are volcanoes, eruptions of the older rocks, metalliferous deposits, and the mechanical dislocations to which chains of mountains owe their origin. These different chemical, physical, or mechanical effects of the internal action of the globe are very probably associated, and it would leave a blank not briefly to notice in this history the labors which have indirectly contributed to illustrate the effects of metamorphism.

§ 1. *Eruptions of Volcanoes.*

The extinct volcanoes of central France, whose identity with existing volcanoes‖ was ascertained in 1751 by Guettard, revealed at a later period to Dolemieu an important fact; it was that volcanic phe-

* Especially in the environs of Saint Martin de Fenouillet. Caractères de la craie dans le sud de la France.—(*Annales des Mines*, 2d series, vol. viii, page 311, 1830.)

† Memoir on the geological position of the principal iron mines of the eastern part of the Pyrenees, accompanied by considerations on the time of upheaval of Canigou and on the nature of the Rancy limestone.—(*Annales des Mines*, 3d series, vol. v, page 307, 1834.)

‡ Memoir on the connexion between the ophites, the gypsums, and the salt springs of the Pyrenees.—(*Annales des Mines*, 3d series, vol. ii, p. 21, 1832.)

Pallassou also had perceived a part of these modifications.—(See p 100 of the work cited above.)

§ M. Keilhau assigned as a cause of these changes, which sometimes extend for 1,000 yards, simple molecular action, without the intervention of heat, nor of emanations from below. He thought that eruptive were only sedimentary rocks situated at a greater depth, and become liquid.—(*Darstellung der Uebergang's Formation in Norwegen*, 1826; *Ueber die Bildung des Granits.—Karstens Archiv.*, vol x, 1837.—*Gæa Norvegica*, 1, 1830.)

‖ Memoir on some of the mountains of France which have been volcanoes.—(*Mémoires de l'Académie*, 1752.)

nomena have their origin under granite and the other primitive formations; that is to say, below the *solid crust* of the globe.* This idea, with which we are now so familiar, appeared new at an epoch when volcanic eruptions were generally considered as isolated, superficial, and insignificant accidents. In fact, the experiment of Lémery on the spontaneous combustion of a heated mixture of sulphur and iron,† or the supposition of the subterraneous conflagration of carbonaceous combustibles sanctioned by the almost sovereign authority of Werner, had led everywhere to the assignment of some local focus as the cause of these phenomena. Buffon himself, the most ardent promulgator of the primitive heat of the globe, took no other view of them. Thus the grand idea of Descartes, which had thus early connected these phenomena with the formation of hot springs and metallic veins, and even with ancient fractures of the earth's crust, had passed into an oblivion scarcely conceivable. And it was by being brought back to this idea through the force of facts that Dolemieu contributed so much to the rapid advance which geology then made in France.

But the human mind is in general not freed from erroneous ideas except by long and successive efforts. It was then believed, and Dolemieu sought to explain it by unfounded hypotheses, that lavas, instead of deriving their heat from internal fires, acquire it by a sort of interior combustion which they undergo on arriving in the atmosphere; that, moreover, they are kept liquid by some kind of flux, such as sulphur. It was necessary that Spallanzani should perform a long series of experiments on the fusion of lavas in crucibles and glass furnaces to overthrow these prejudices.‡ The exactitude and the genius for observation of the illustrious professor of Pavia showed itself in his studies on the nature and origin of volcanic rocks, as well as in his brilliant discoveries in animal economy; and he is one of those who had the merit of introducing the experimental method in geology.§ Since then Alexander Von Humboldt, after having ex-

* 1st. The products of volcanic action belong here (in Auvergne) to a mass of matter which differs from the granites and lies below them. 2d. Volcanic action has exerted itself here under the granite, and has been at work in the depths much inferior to it. 3d. Granite is not the most ancient rock, since it is of necessity posterior to that which supports this mass.—(Report made to the Institute on the travels of the years 5 and 6, *Journal des Mines*, vol. 7, p. 397, 1798.)

A few lines further on (p. 398) Dolomieu adds, "that there are reasons for extending these conclusions to all other volcanoes, without regard to the nature of the soil that surrounds them. Volcanic agents everywhere have their seat at great depths below the *consolidated crust* of the earth.

† Mémoires de l'Academie des Sciences, 1700.

Afterwards Pallas was led to refer the cause of volcanoes to the crystalline schists containing pyrites, like those he had had an opportunity of seeing in the Ural.

‡ Voyage dans les Deux Siciles, 1792, introduction and fourth volume.

§ Spallanzani further discovered the *marine acid* (chlorhydric acid) among the gases which puff up the lavas, and hydrogen in the natural fires of Barigazzo.

In closing his observations on lavas, Spallanzini reproduces this remarkable opinion of Faujas-Saint-Fond. "It is not impossible that water united with fire may bring about combinations unknown to, and unattainable by art."—(Vol. iv, p. 75.)

plored the immense volcanoes of the two Americas, and Leopold de Buch, who so profoundly studied the structure of the Canary islands, have, upon other considerations, still further evinced the power and universality of volcanic action, and the varied forms under which it manifests itself.

§ 2. *Eruptive rocks.*

Auvergne, which, like Scotland, presents in its geological constitution features that command attention immediately, has likewise furnished the first well-attested examples of rocks which, without having come from the crater of a volcano, have, beyond a doubt, had an eruptive origin. Desmarets recognized the igneous formation of basalt during an excursion that he made in that country in 1763, and published it in 1768;* seventeen years, therefore, before the publication of the first memoir of Hutton. It was then that the long discussion took its rise between the neptunians and the plutonists, a discussion which sometimes degenerated into a keen dispute, and which, it is remarkable, was prolonged for more than half a century after the eruptive origin of basalt had been ascertained in Auvergne, in Italy, by this same Desmarets, and in the Hebrides by his successor, Faujas Saint Fond. It is evident from a report made by Cuvier, in 1808, that the arguments of the school of Werner still preserved their prestige even in a country where facts supported by so much evidence plead on the opposite side, and where such remarkable examples of the intrusion of rocks had been recognized by Strange, Hutton, Haussmann, and Leopold de Buch.† Without doubt the question would have been more speedily settled if European communications and relations had in those days presented the same facilities as in our own.

§ 3. *Formation of metalliferous deposits.*

Since it has been recognized that metalliferous veins, as Descartes had inferred, have been filled by exhalations coming from the depths of the earth, their study has contributed to throw light on the subject with which we are occupied; of this we shall see the proof further on.

§ 4. *Mechanical dislocations of the crust of the earth.*

The formation of mountain ranges presents in its history phases not less singular than that of eruptive rocks.

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* Mémoires de l'Académie, 1768.

† "It was in conformity with the observations of Desmarets that a volcanic origin was for a long time attributed to all the basalts, rocks very similar to certain lavas. It appears, however, that the formations which resemble lavas do not all have the same origin. Such are the rocks called *wacks*, which cover great tracts in certain parts of Germany; they are there perfectly horizontal, have no elevation that could be regarded as a crater, and rest upon very combustible coal, which they have not altered. They are not therefore volcanic. Werner had perfectly proved these facts, and as a result of his observations a multitude of formations lost the origin attributed to them The opinion of Hutton and James Hall that they were melted *in situ* at the time of a general and violent heating of the globe will hardly hold good." Edition in 8vo., pp. 171 and 172. Desmerets was a witness to all this long discussion and of the report which thus condemned his conclusions, for he died in 1815.

Descartes had given a new proof of his admirable penetration of mind in attributing the dislocations of the *terrestrial arch* to the cooling and contraction of the internal mass.*

Stenon, relying on the precise observations which he made in Tuscany, thought, as early as 1669, that he had grounds for concluding that the stratified formations had lost their first horizontality, probably from the influence of subterraneous vapors.† He published his work after having remained two years in Paris in company with Descartes,‡ whose system made a profound impression upon him.

The beautiful conception, however, of the French philosopher relative to the origin of the asperities of the globe, notwithstanding the support given to it by Stenon, was for a long time slighted, and gave place to hypotheses which we now know have no foundation. Leibnitz himself, although founding his opinions on the ideas and observations of these two great men, preferred to attribute the drying up of the ancient beds of the sea to the infiltration of a part of the water into abysses which he supposed to have been produced by the ebullition of the primitively melted mass.

Buffon, although attributing much to primitive heat, was not more happy than Leibnitz in the two opposite and contrary opinions which he successively published on the formation of mountains.§ It was, in fact, only after a century that Hutton, James Hall, and Saussure, were brought back by new paths to the very prolific idea of Descartes. ‖ It still, however, remained vague, unsettled, and veiled, as it were, by the school of Werner, when Leopold de Buch, and afterwards Elie de Beaumont, gave it definitively a fundamental importance, by

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* "The fissures enlarging, the external parts could no longer sustain themselves, and the arch breaking up suddenly made it fall in large pieces on the superficies of the interior; but as this superficies was not sufficiently large to receive all the pieces in the same situation in which they previously were, it was necessary that some should fall to one side and should rest the one on the other."—(§42, page 322, Works of Desmerets, edition cited above.)

† The work published by the Danish savant, alike anatomist and geologist, under the title, *De Solido intra Solidum naturaliter contento, Dissertatio Prodromus*, in an extent of 76 pages only, constitutes, by the justness and importance of the observations which are noticed, by the connexion and vigor of its reasoning, the precision of its style, and the somewhat geometrical form that its author has given it, one of the most remarkable works on geology, as Dr. Bertrand de St. Germain has well remarked.

A long time since Eliè de Beaumont called attention to the principal conclusions of Stenon in the *Annales des Sciences Naturelles*, vol. xxv, 1832.

Stenon also distinguished volcanic from stratified rocks, and, among these last, ancient and recent beds.

‡From 1664 to 1666.

§ Either in the sea, by the motion and sediment of the waters, (*Théorie de la Terre*,) or by fire at the time when the globe was still incandescent and consequently long before there were seas and living beings, *Epoques de la Nature*, which, as we know, appeared nearly thirty years after the first work.

‖ We are indebted, however, to Robert Hooke for very exact observations in regard to earthquakes, 1705; to Lazzaro Moro, 1740; to Fichtel, *Ueber die Karparthen*, 1791; Heim, *Geologischen Beschreibung des Thuringewalds*, third part. This last observer had entered into a number of ingenious considerations on the possibility of the upheaval of mountain chains by basalts and porphyrys, on the sublimations of metals and minerals in rocks, as well as on the alterations produced in different rocks by igneous eruptions.

giving it precision and at the same time supporting and developing it by numerous and exact observations.*

It was discovered, besides, that the formation of thermal and gaseous springs, as well as of metalliferous veins, had some connexion with this system of fracture, even in regions which are not traversed by eruptive rocks.†

§ 5. *Internal heat of the earth proved by direct measurement.*

Although the internal heat of the earth forms the foundation of the entire system of Hutton, it was not until later that this capital fact was verified in a positive manner, that is, by measurements sufficiently exact and numerous enough to establish the truth of it beyond a doubt. By an exception which is rare in the sciences of observation, speculative ideas, had, in this particular case, anticipated the discovery of the reality. Before the first memoir of Hutton there existed scarely anything relative to the increase of temperature below the earth's surface, but the observations cited by Kircher in 1644,‡ and those made by Gensanne in 1749, in the mines of Giromagny. The measurements made in Saxony by Freiesleben and Humboldt date from 1791; they were, therefore, only anterior to the second edition of the work of the chief of the Scotch school. From this time observations have succeeded one another in great number up to the present day; the principal of which are due to Aubuisson, de Trebra, Arago, Dulong, R. Fox, Boussingault, Reich, Delarive, Ermann, Walferdin, and some others. There were still, however, causes of error which raised objections to the main fact, when Cordier, in his *essay on the temperature of the earth*, (read in 1823 before the Academy of Sciences, and published in 1827,) overcame the last doubts. Before this publication, this savant, whom the aspect of Teneriff had long before confirmed in the ideas which he had imbibed from Dolomieu, had rigorously determined by the aid of a new process of analysis the mineralogical constitution of volcanic rocks, and the analogy which unites them all, even when they are of a different composition.§

Finally, we know that several geometricians have sought to study by calculation the condition of the interior of the globe at different epochs.

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* The superposition of granite and porphry in the formations of transition of the environs of Christiania, which Haussmann, observed in 1805, and the slow and gradual rising of the soil of Sweden, were irresistible arguments to Leopold de Buch.

Among the oldest observations of the same kind we must cite those of Count Marzari Pencati, who had accompanied Fonjas Saint Fond to Italy, and who had given his attention to the superposition of the rocks reputed primitive and to stratified formations, particularly in Southern Tyrol, (1819.)

† Hoffman was one of the first to clearly point out this relation for the gaseous springs of the north of Germany.—(*Nordwestliches Deutschland*, 1830.)

‡ The same year that Descartes published his ideas on internal heat. These first experiments are due to Schapelmann, Bergmeister at Schemnitz, in Hungary.

§ Recherches sur les différents produits des volcans.—(*Journal des Mines*, vol. xxi, p. 249, 1807; vol. xxiii, p. 35, 1808.) Mémoire sur les substances dites en masse qui entrent dans la constitution des roches volcaniques de touts les âges.—(*Journal de Phyisque*, vol lxxxiii, 1816.)

I can only cite here the important investigations made for this purpose by Fourier, Lagrange, Laplace, and Poisson.*

In short, it has been by several very different paths that we have come to admit the idea of a central heat as a fundamental idea in geology, and to recognize the importance of the doctrine of metamorphism which attaches itself to it as an effect to its cause.

CHAPTER V.

MODIFICATIONS WHICH HAVE TAKEN PLACE SINCE THE TIME OF HUTTON IN IDEAS RELATING TO METAMORPHISM.†

Up to the time to which our third chapter brought us, that is to say, during the first third of this century, heat aided by certain volatile substances had been considered, after the example of Hutton, as almost exclusively the cause of metamorphic phenomena. It was thought that the transformed rocks had crystallized, after having been softened and perhaps penetrated by the neighboring or subjacent igneous masses.‡ We shall see further on that all the synthetic experiments of metallurgical works and of laboratories seemed completely to ratify this view of the subject. Certain more attentively observed facts, however, arose to combat this generally admitted hypothesis. It was in vain that, to do away with the serious objections which were raised, the action of cementation, of electricity,§ and of the possible solution of certain silicates, the one by the other, were appealed to. Grave doubts had sprung up, and from that time they only continued to increase. At this moment a new way seemed to open; we shall presently see who were those that first entered upon it.

It was first ascertained that metallic veins could not, for the most part, have been filled either by means of fusion or of sublimation, but by matters held in solution in water which was at a high temperature.

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*Note sur le rapport qui existe entre les refroidissement progressif de la masse du globe terrestre et celui de la surface.—(*Comptes Rendus*, vol. xix, 1844, and *l'Institut*, p. 32, 1845. Mémoire sur la théorie mathématique des températures terrestres.—*Annales des Chimie et de Physique*, vol. ii, p 387.) Several important memoirs by Mr. Hopkins and Mr. Hennessy.

†Instead of attributing, as did Hutton, the heat subsequently acting upon certain sediments to the temperature of the bottom of the sea, which we now know to be very low, it is explained by other causes, as we shall see in the third part of this work.

‡ Boué. mémoire cited above, 1824.—(*Annales de Chimie et de Physique*, 2d series, vol. lx, p. 291, 1835.—*Societié des Sciences de Lyon*, 1845.—*Bulletin de la Societié Géologique de France*, 2d series, vol. ix, p. 222.)

Fournet, who represented this school in France, compared these phenomena to the absorption of the sides of a cupell. He tried to prove by experiment that argillaceous schists submitted to the combined influences of heat and of certain fusible bodies, will be penetrated by them with the greatest ease, and will thus undergo chemical action. The quartz nodules (ganglions) found in micaschists were due to this cause. Quartz, in consequence of a peculiar kind of *surfusion*, might be consolidated after more fusible substances. It is thus that Fournet explains the alteration of the eruptive by the surrounding rock, an alteration which he calls *endomorphism*.

§ Virlet has attributed the effects of metamorphism to electro-chemical action; developed, perhaps, by the aid of high temperature.—(*Bulletin de la Societié Géologique de France*, vol. v, p. 313, 1835.)

The remarks of Longchamp on the relation between the thermal springs of Chaudesaigues and the lode of iron pyrites from which they spring*, and on the other hand, the ingenious experiments by which Becquerel was able by the humid process to imitate galena, sulphuret of antimony, and other minerals of metallic veins, contributed to recall ideas in this direction.† Since 1833, Fournet, after having studied the metallic veins of Pontgibaud, in Auvergne, concluded that they had probably been filled by the incrustations of mineral waters.‡ The mineralogical resemblance between the veins of Saxony and the silicious and metalliferous deposits of the lias, in Bourgoyne, which, according to all probability, could only have been made in the wet way, confirmed this opinion, as has been shown by Baron de Beust.§ Besides, as Elie de Beaumont had a long time before said, in his lectures at the School of Mines,‖ metallic veins are generally found near lines of contact of the stratified with the unstratified rocks which have penetrated them; and such is also the usual position of hot springs, which at the present time very frequently deposit stony or metallic substances in the channels through which they run. The important conclusion to which this collation of facts led, on the mode in which metallic veins have been filled, differed in essentials still more from the hypothesis of Werner, than from those of Descartes and of Hutton.

Moreover, the study of the metamorphic formations themselves brought to light circumstances which the dry process could not explain, and especially the extent and uniformity of the transformed masses, the mode of dissemination, and the arrangement of the minerals which were formed in these rocks, which were ascertained not to have been softened and never to have been submitted to a very high heat. This last induction results from different facts which will be noticed in the third part of this work.

Durocher, in the sequel to a memoir published in 1846,¶ where he recorded many observations of his own, attributed the effects of metamorphism to slow action and to molecular transference very anal-

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* *Annales de Chimie et de Physique*, vol. xxxii, p. 294, 1826.

† *Annales de Chimie et de Physique*, October, 1829; September, 1832; May, 1833.

‡ *Bulletin de la Societié Géologique de France*, vol. v, p. 188—vol. iii, p. 251.

In 1837 Mr. Robert Were Fox (*Report of the Royal Cornwall Polytechnic Society for* 1836) showed how lodes appear to owe their origin to hot springs; he attributed their formation to thermo-electrical effects—the traces of which he thought he had found in the experiments he had made on metallic veins.

De la Beche adopted these ideas in his *Geological Report on Cornwall and Devon*, 1839.

§ *Kritische Beleuchtung der Wernerschen Gangtheorie*, p. 6, 1840.—The author points out the striking resemblance of the deposits contained in the beds of arkose of Burgundy, with the veins of Freyberg.

The interesting observations of Bischof on the formation of iron pyrites and on hot springs have contributed to confirm this result. The memoir which he published on the filling up of metallic veins, bears date 1843.—(*Ueber die Entstehung des Quarzes und Erz Gänge.*)

‖ *Explication de la carte Geologique de France*, vol. 1, p. 43, 1841.

¶ Etudes sur le métamorphism, *Bulletin de la Société Géologique de France*, 2d series, vol. iii, p. 547, 1846. Métamorphism dans les Pyrénées.—(*Annales des Mines*, 3d series, vol. vi, p. 78.)

ogous to cementation. Other considerations which tended to the conclusion that water had probably served as a vehicle of the heat are due to Fuchs, Silliman and Dana,* and to Schalfaütl.† Nor must we fail to speak of the labors of Bischof, who, possessing great critical judgment and knowledge of the resources of chemistry, did not cease, during many years, to combat the ultraplutonic ideas which were in vogue at the time of which we are speaking.‡ Volger also, following this example, has brought numerous arguments to bear against the action of heat, which he even entirely rejects.

After having studied the volcanic phenomena of Iceland in all their principal peculiarities, Bunsen called attention to the action of gas and water at temperatures comparable to those of the existing fumaroles, and considered them as a cause of metamorphism at least as powerful as heat.§ Cotta likewise, in describing the great examples of metamorphism in the Alps, remarks, with justice, that such effects cannot have been produced without the co-operation of water, which proceeded either from the humidity of the rocks or from hot springs.‖ Still later, Delesse has examined, by help of the chemical analysis, the nature of eruptive rocks and of those which surround them at their point of contact.¶ Judging from a great number of facts, he has also come to the conclusion that trap and granitic rocks appear to have modified the rocks which surround them, less by their own heat than by aqueous emanations which were charged with different saline or acid substances.**

At the same time that the observations of which we have just spoken tended to cause the action of water in metamorphism to be admitted, it was recognized, on the other hand, that granite, the eruptive rock to which the most energetic power of transformation over the surrounding masses had been attributed, could not itself have

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* If a rock is calcined 12 yards in depth, it must have been melted not less than half this distance, where heat has been the cause of the transformation. The heat appears to have had water for a vehicle.—(*Silliman's Journal*, vol. xlv, 1843.)

† *Die neuesten geologischen Hypothesen und ihr Verhältniss zur Naturwissenschaft überhaupt.* Leonard's Jarbuch, p. 858, 1845.

‡ A work very rich in observation by M. Bischof was published from 1847 to 1855, entitled, *Lehrbuch der chemischen und physikalischen Geologie.*

One of the principal arguments which Mr. Bischof develops against the dry way, consists in the production of minerals resembling those of the crystalline rocks as pseudomorphs or epiginies, that is to say, in conditions where the minerals could not have been formed but in the wet way. He does not, however, attribute an important part to the vapor of water, after remarking its feeble action on rocks both in the burning mine of Dutweiler, which has been on fire for two centuries, and in the soffionis of Tuscany.

§ Ueber den innern zusammenhang du pseudovulkanischen Erscheinungen Islands. *Annalen du Chimie und Pharmacie*, vol. lxii., p. 1, 1847. Ueber die Processe der Vulkanischen Gesteinbildungen Islands. *Pogg. Ann.*, pp. 83, 197, 1851; *Leonhard's Jarb.*, p. 537, 1851.

‖ *Geologische Briefe aus den Alpen*, p. 243, 1850.

¶ Etudes sur le métamorphism.—(*Annales des Mines*, 5th series, vols. xii and xiii, 1857 and 1858.)

** It is a fact analogous to that which proves the association of metalliferous deposits with eruptive rocks.

been produced by a purely igneous fusion. Breislack,* Fuchs, and Boucheporn, Schafhaütl and Scheerer,† concluded from the abundance of isolated grains of quartz, from the manner in which its elements are grouped together, in fine, from the presence of pyrognomic minerals sometimes found in it, that granite originally contained water, and, moreover, that the presence of this water could have prolonged the plasticity of the mass much below its point of actual fusion. Elie de Beaumont showed, in addition, that granite probably owes its mineralogical composition to different substances, which, since its consolidation, have partly disappeared with the water, such as compounds of chlorine, fluorine, and boron. Thus the mode of formation of granite takes a character intermediate between the origin of metallic veins and that of volcanic and basic eruptions,‡ and the eminently crystalline condition of this rock is not caused by its having been solidified at great depths.

The ingenious observations of Sorby on the liquids enclosed in the microscopic vacuities of rocks have entirely confirmed the intervention of water and heat in the formation of granite.§ It will be remembered that the attention of Davy had been already arrested by the minute drops of liquids, accompanied by gaseous matters, which may be distinguished by the naked eye in certain crystals, and that their examination had led him to suspect that water, with the aid of pressure, had contributed to the formation of rock crystal. Later, Sir David Brewster has given greater extent to this species of researches.‖

Another order of facts which has still further confirmed the induction that granite might have been plastic without the intervention of a very high temperature is, that the rocks into which it has been in-

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* Breislack, although approving with energy the ideas of the neptunists, remarks, that from the order of consolidation of the elements of granite, and the presence of drops of liquid which quartz sometimes contains, it is difficult to admit that this rock has ever been in a real state of fusion. "Why could not water and fire have co-operated together at different times in the production of our earth, and sometimes even have joined their efforts?"—*Institutions Géologiques*, (French translation,) vol. i, p. 68, 1818.

Thus he sought to follow out the idea of which Faujas-Saint-Fond and Spallanzani had already caught a glimpse, in bringing together two agents which are in no way incompatible, as his two antagonists pretended, and which he, on the contrary, saw intimately associated in the volcanoes of which he had made a profound study. "If," says Breislack, "experiments ought to serve as a guide to philosophy, and if those which are carried on in volcanoes are the most important which we can collect, why may we not use them?"

† Discussion sur la nature plutonique du granite et des silicates cristallins qui s'y rallient.—(*Bulletin de la Societié Géologique de France*, 2dseries, vol. iv, p. 468. Réponse aux objections de Durocher, Idem, vol. vi, p. 644, and vol. viii, p. 500.)

‡ Note sur les émanations volcaniques.—(*Bulletin de la Societié Géologique de France*, 2d series, vol. iv, p. 1291.) Elie de Beaumont describes the plastic state of granite under the name of *gelatinous surfusion*, p. 1310.

§ Sorby on the microscopical structure of crystals, &c., *Quarterly Journal of the Geological Society*, p. 453, 1858.—(*Comptes rendus de l'Academie*, vol. xlvi, p. 46.)

‖ *Annales de Chimie et de Physique*, vol. xxi, p. 182, 1822.
The topaz of Brazil, according to Sir David Brewster, also contains different liquids.—(*Poggendorff's Annalen*, vol. vii, p. 493.)

jected in the state of paste sometimes show but a scarcely perceptible alteration, even in their immediate contact with it.*

The eruptive rocks other than granite in like manner appear to have been formed through the co-operation of water, and for the most part at a temperature much lower than had been supposed.† But if the eruptive rocks themselves have been dispossessed of the prestige of high temperature which they have so long enjoyed, much less could their heat alone have produced the energetic effects which are often attributed to them.

Thus by three different ways the conclusion has been arrived at that water, aided by certain substances, has nearly everywhere been a powerful co-operator with heat in the metamorphism as well as in the formation of the principal metalliferous deposits, and of the eruptive rocks themselves.

I have spoken of the first observations which disclosed the metamorphic state of certain dolomites. Since then this origin has been attested in different countries. Lardy, in his excellent memoir on the geognostic construction of St. Gothard, (1829,) remarks that dolomite and gypsum must have had some connexion with the opening of the crevasse which forms the valley of the Tessin.‡ The polypiers changed into dolomite, and found at Gerolstein by de Verneuil, have, moreover, furnished in favor of the transformation of this rock an argument of which Elie de Beaumont long since showed the weight.

Elie de Beaumont, supporting his idea on the remarkably porous and cracked state of many dolomites, such as those of Tyrol, Lugano, and of Franconia, proved as long ago as 1829 that this structure was owing to an epigenesis, and the substitution of carbonate of magnesia for carbonate of lime in equivalent proportions.§

As to the manner in which this substitution may have taken place, the study of the dolomites and gypsums of the valley of the Tessin had suggested to de Collegno, in 1834, that the carbonate of lime had probably been transformed simultaneously into gypsum and dolomite by the action of mineral waters, the traces of which he even investigated in the Val. Canaria.‖ It was this idea which afterwards led Haidinger and de Morlot to imitate dolomite¶ artificially.

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* M. Delesse has recently well summed up the facts which prove it, including with them his own observations on the metamorphism of contact.—(*Bulletin de la Societié Géologique de France*, 2d series, vol. xv, p. 728.)

Henry Rose has also recently put forth arguments to the same purpose: Ueber die Verschiedenen zustände der kieselsaüre Poggendorff's Annalen, 1859.

† The above cited memoir of Mr. Delesse enumerates the principal proofs.

‡ *Denkschrift der Schweizerischen Gesellschaft*, vol. i, p. 200, 1829.

§ Note sur la forme la plus ordinaire de objections relative à l'origine de la dolomie.—*Annales des Sciences Naturelles*, vol. xviii, p. 269, 1829.—*Bulletin de la Societié Géologique de France*, vol. viii, p. 173, 1826.

‖ Notes sur quelques points des Alpes Suisses —(*Bulletin de la Societié Géologique de France*, vol. vi, p. 110, 1834.)

¶ Some savants, among others, Daubeny, Leube and Grandjean, consider dolomite as the result of the action of the atmospheric waters on magnesian limestone.

Others, as Rozet and Puggaard, have attributed an eruptive origin to certain dolomites which form veins and contain embedded fragments. (Framont, Grisons, Fulda, Helsingfors, and Sorrente.)

In many stratified formations, however, such as the trias, dolomite is found in regular beds; if there has been a substitution it must have been at the very time of its deposit. This reservation has been made by Elie de Beaumont, especially in favor of the dolomites of the Marnes Irisées.*

It has been also discovered that in certain formations the gypsum resulted from a transformation of the limestone. I will mention only the observations of Hoffmann and of Coquand on the gypsums produced by the fumaroles of the Lipari islands and in Tuscany, and those of Dufrenoy on the gypsums associated with the ophites of the Pyrenees.

The formation of the dolomite, of anhydrite, and of rock salt, has given occasion to very numerous works, which it is impossible to mention here.†

CHAPTER VI.

METAMORPHISM OF STRUCTURE.

In the time of Hutton it had not been remarked that the foliated structure so frequent throughout entire masses of rocks, results from an action posterior to their formation, and consequently thus constitutes metamorphism.

The distinction which we now recognize between a foliated structure and stratification had, however, been described by different authors at the commencement of this century, among whom, Lasius,‡ Voigt,§ Mohs,‖ de Hoff,¶ and Schmidt** ought to be cited. In England, John Phillips had clearly recognized the difference between the *true* and the *false* cleavage. Professor Sedgwick†† afterwards confirmed and generalized the fact, showing that in Wales the plates are very generally oblique to the stratification.‡‡

Another very remarkable circumstance, which was signalized by Mr. Sedgwick, is the astonishing constancy with which the plates conform to one another over extensive tracts, and even amidst the most marked convolutions of the beds to which they belong. This observation has been completely confirmed by Studer and Forbes in

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* Observations sur les différents formations qui, dans le systèm des Vosges, séparent la formation houillère de celle du lias.—(*Mémoires pour servir à la description géologique de la France*, vol. i, pp. 78, 153, 192.)

† Among the principal I mention the work of d'Alberti, the memoirs of Fournet and of Boué —(*Ueber die Dolomite. Sitzungs Berichte der Acad. der Wissens. zu Wien*, vol. xii, p. 422; 1854.)

‡ *Das Harzgebirge.*

§ *Praktische Gebirgskunde*, 1797.

‖ *Molls Ephemeriden*, vol. iii, p. 71; 1807.

¶ Slate quarries of Lehesten, in Franconia.

** In Westphalia.

†† On the chemical changes produced on the aggregate of stratified rocks.—(*Transactions of the Geological Society*, vol. iii, p. 354; 1835.)

‡‡ Mr. Parrot, engineer of mines, according to a manuscript report of 1826, noticed the same distinction in the slates of the Ardennes.—(*Explication de la carte géologique de France*, vol. i, p. 262.)

the Alps; by Sir R. Murchison and Darwin in the Andes; by Rogers* in the Appalachian mountains, and by other geologists.

There exists, however, between the position of the lamellæ and that of the beds, relations which Baur and Sharpe have with great sagacity brought to light.

The cause of the development of the foliated structure of the phyllades has been attributed to crystalline, polar, or electric agencies. These vague hypotheses could hardly find foundation but in the fact announced by R. Fox, that wet clay in presence of electrical currents will become perceptibly foliated.† These causes, which may be qualified as occult, have, however, been adopted by eminent savants, such as Sedgwick, Sir H. de la Beche,‡ Sir J. Herschel,§ Hopkins,|| and Scheerer.¶ This is easily explained, for the remarkable fact which was more particularly calculated to lead to a right explanation was only recently discovered by Baur.**. This geologist was the first to show, in his remarkable work, (1846,) that the cleavage took place at the time of the convolvement of the beds, and that it seems the result of a pressure normal to that which developed the convolutions. It was not until a year later that Sharpe, to whom the priority has often been given, came to the same conclusion, founded on other very precise observations on the distortions produced upon fossils. He afterwards established the same fact for rocks in which no organic remains are found.††

The first attempt to imitate this phenomenon mechanically was made by Professor Sorby, to whom we owe other ingenious researches.‡‡ He discovered by a microscopical examination of the disposition of their elements, as well as by the compression of certain thin layers, that the schistose rocks had undergone compression. Professor Tyndall went still further; he produced a foliated structure exactly like slate in different plastic substances, as pipe-clay and wax, by compressing and submitting them to a process of rolling.§§ It was thus, without doubt, that this expert physicist was afterwards induced to pay attention to the structure and movement of glaciers.

I conclude by calling to mind that Laugel, engineer of mines, and Professor Haughton have sought to subject to calculation the effects of pressure which have produced a schistose structure.

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* *Proceedings of American naturalists and geologists*; 1845.

† *Report of the Cornwall Polytechnic Society*; 1837. *Memoirs of the Geological Survey of Great Britain*, vol. i, p. 433.

‡ *Geological Report on Cornwall and Devon*, p. 181; 1839. The polar forces, the author supposes, are probably in connexion with terrestrial magnetism.

§ Lyell. *Manual of Geology*, 5th ed., vol. ii, p. 448.

|| *On the connexion of geology with terrestrial magnetism.*

¶ *Karstens Archiv. fur Mineralogie*, vol. xvi, p. 109; 1842. *Geological Observations on South America*, p. 168.

** *Karstens Archiv.*, vol. xx, p. 398; 1846.

†† *Quarterly Review of the Geological Society of London*, vol. iii, p. 74; 1847. *Geological Proceedings*, November, 1854.

‡‡ In laminating clay, in which he had scattered pellicles of oxide of iron, Sorby noticed that they placed themselves perpendicularly to the pressure.—(*Edinb. Phil. Journal*, 1853. *Quarterly Review*, vol. x, p. 73; 1854.)

§§ Comparative view of the cleavage of crystals and slate rocks.—(*Philosophical Magazine*; 1856.)

The history of the succession of ideas on the formation of lamellæ in schistose rocks may serve for instruction in a philosophical point of view. We see how easy it is, especially in geology, for the ablest minds to err when they deviate from the path of observation and of facts. Moreover, even after the influence of mechanical pressure had suggested the probable cause of the phenomenon, it was ten years before one of the most simple experiments which it would seem ought to have been immediately thought of, was brought forward to verify this induction.

CHAPTER VII.

NOTICE OF OTHER OBSERVERS WHO HAVE INVESTIGATED METAMORPHISM.

The facts upon which the doctrine of metamorphism is based have been observed in all regions of the globe, especially during the thirty years that attention has been called to the subject by many other geologists, some of whom have very much exaggerated or falsified the bearing of the phenomenon. The observers are so numerous that it would be impossible, without lengthening this work beyond measure, to do more than notice the principal names. They are :

In France—Alexander Brongniart,* d'Omalius, de Bonnard,† Fournet,‡ de Boblaye,§ Virlet,‖ A. Burat, de Boucheporn,¶ Gras,** Charles Deville, Coquand,†† Puton,‡‡ Gueymard, Lory, Angelot, Drouot, Delanoue.

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* Sur les ophiolites ; sur les caractères zoologiques des formations.—(*Annales des Mines* 1821.) Sur le Cotentin —(*Journal des Mines ;* 1815.)

† *Annales des Mines*, 1st series, vol. viii ; 1824.

‡ Besides the memoirs, in which Fournet has published since 1836 very many precise observations and ingenious suggestions on metamorphism, as I have said above, this learned professor has collected at the Faculty of Sciences of Lyons an interesting collection which has been studied by many savants I shall again cite his *Etudes sur les Alpes*, (1845 to 1849.)

§ The discovery in the formations of transition of schists, containing at the same time macle and many fossils, by Boblaye, has introduced a new element really positive into the question of metamorphism.– (*Comptes Rendus de l'Academie*, 1838. *Bulletin de la Société Géologique*, 1st series, vol. x, p. 227.)

‖ Virlet long since made known numerous effects of metamorphism in Greece, and has even extended the ideas on metamorphism to the utmost in applying them to eruptive rocks, such as granite, protogene, trachite.—(*Geologie de la Grece*, pp. 67, 184, 294, 298, 304, and 306. *Bulletin de la Société Géologique de France*, vol. vi, pp. 279 and 313, 1834 ; vol. vii, p. 310, 1835 ; 1st series, vol. xiv, p. 501.)

¶ De Boucheporn, in exaggerating the action which I had previously attributed to fluor, has admitted that, by heating, the elementary matter of granite had given off fluorites of silicium and of the alcaline metal, which are the cause of the transformation of the neighboring rock, (page 271 of his work.) His original idea on the action of cyanogen in the formation of the globe merits attention.

** Gras has made important observations on the crystalline rocks of the Alps, Dauphin and Savoy, and considered the spilites of this chain as metamorphic.

†† Coquand has furnished very interesting facts, particularly in describing the solfataires of Tuscany, and in studying the formation of gypsum and of dolomite.

‡‡ The work of Puton on the metamorphisms which have occurred in certain rocks of the Vosges (1838) contains many well observed facts.

In England—Sir James Mackenzie, Jameson, Conybeare, Buchland, Greenough, Sir R. Murchison,* Sedgwick, Sir H. de la Beche,† John Phillips,‡ Colonel Portloch, Doubney, Berger, Poulett, Scrope, Henslow, Ramsay.

In Germany—Humboldt, Naumann,§ de Leonhard, Mitscherlich, Haussmann, W. Haidinger,‖ B. Cotta,¶ G. Rose, Abich, d'Alberti, de Morlot, Blum,** Credner.

In Switzerland and Italy—Escher de la Linth,†† de Charpentier, Lardy, de Collegn,‡‡ de la Marmora, A. Favre,§§ de Marignac, Théobald.

In the Scandinavian peninsula—A. Erdmann.

In America—Rogers, Hitchcock, Whitney, Sir W. Logan, Sterry Hunt.

CHAPTER VIII.

HISTORY OF SYNTHETICAL EXPERIMENTS, TENDING TO ELUCIDATE THE QUESTION OF METAMORPHISM.

The progress which we have just sketched has cost more effort than we could at present suppose, for there was scarcely any other guide than purely geological facts, elucidated by analogy and induction. We should have reposed in views of necessity very vague, if synthetical experiment had not followed direct observation, to substantiate and complete it.

It has seemed best to me to enumerate by themselves, and with some details, the principal attempts which have been made up to this time to imitate minerals and rocks artificially. They throw light on the different processes which may have been brought to bear in the very various reactions of nature; besides, that these are the first steps in a method which appears destined to reveal very important facts for the history of formations and for metamorphism. Leibnitz, it is true, had profoundly appreciated the utility of experiments for the interpretation of the formation of strata, and compared, as far as he was able, the

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* The works of Sir R. Murchison on the silurian formations of England, on the Alps, and the Ural, present numerous and important examples of metamorphism.

† Sir H. de la Beche, in his *Theoretical Manual*, his *Art of Observing*, his *Geological Researches*, and his *Geological Report on Cornwall and Devon*, has published a great number of judicious and ingenious observations on metamorphism, as on all other subjects of geology.

‡ Among the works of Mr. J. Phillips, we must here make mention of a report on schistose cleavage, inserted in the memoirs of the *British Association*.

§ Besides his observations made in Saxony and Norway, Naumann has treated metamorphism in detail in his excellent work on *Geognosy*.

‖ Haidinger proposes to distinguish *anogenous* and *catogenous* metamorphism, according as they occur near the surface or at a great depth.

¶ Especially in the *Geologische Briefe aus den Alpen*.

** In his studies on the pseudomorphs, Blum has described many facts akin to metamorphism.

†† Numerous observations made in Switzerland with Studer.

‡‡ *Sur le métamorphisme des terrains de sédiment.* Bordeaux; 1842.

§§ *Notice sur la géologie du Tyrol allemand;* 1849.

products of nature with those of the laboratory;* but it was under the inspiration of Hutton that the first important synthetical experiments were undertaken.†

§ 1. *Fusion and cooling of rocks.*

Buffon had rigorously established, by direct experiment, that granite and the principal crystalline rocks can be *vitrified.* He thought that these immense masses of "*natural glass*" had acquired their crystalline state after very long annealing.‡ At the end of the last century Sir James Hall, at the same time that he was studying, as we have before seen, the combined influence of heat and pressure on limestone, undertook numerous experiments with the view of testing whether, as the adversaries of Hutton pretended, the rocks formed by fusion should have remained vitreous.§ He discovered, as Buffon had foreseen, that certain silicates, instead of becoming vitreous, may, by slow cooling, become crystalline and assume a stony appearance, similar to that of eruptive rocks. These experiments, which were continued by other savants, proved further, that a vitreous mass can even crystallize without passing through a state of fusion.‖

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* "It will be, in our opinion, an important work, to carefully compare the products taken from the bowels of the earth with those of laboratories; for then will the striking relations which exist between the products of nature and those of art be made visible to us. Although the inexhaustible Author of nature might employ different means for bringing about what He wills, He delights in consistency amid the variety of His works; and to have found the means of reproducing them is really a great step towards the knowledge of things. *Nature* is only *art on an extended scale.*"—(*Protogæa,* French translation cited above, § 9.) "Do not these general laws of the physical world operate in our laboratories as well as in the interior of mountains?"—(*Saussure, Voyage dans les Alpes,* § 750.)

† The experiment by which Lemery, in 1700, tried to imitate volcanic phenomena, by heating a mixture of iron and sulphur in damp earth, was founded on a false resemblance, and only led to an entirely erroneous conclusion; it made, however, a sufficient sensation to justify an allusion to it.—(*Mémoires de l'Académie des Sciences,* 1700.)

‡ *Histoire naturelle des minéraux.* "*These vitreous substances,*" he says, "melt without addition at the same degree of heat as our artificial glass." Buffon had, besides, remarked that feldspar is much more fusible than the other elements of granite.

Leibnitz had, it is true, previously said that the earth and the stones submitted to fire yield glass; that glass is but the base of the earth, (*Protogæa,* § 3;) but he here confounded all rocks, including limestone, silex, and sand, and there is a wide interval between this vague conception and the first precise experiments made by Buffon.

I have mentioned above (chapter iv, § 1) the experiments of Spallanzani on this subject.

We must also cite the experiments made by Buffon on the cooling of spheres of different dimensions—some of metal, some of sandstone or marble—in order to represent the conditions of the cooling of the terrestrial globe. Newton had before announced his intention to make experiments of this kind.

G Bischof, with the same end in view, made a series of interesting observations of the fusion and cooling of spheres of basalt.—(*Die Wärmelehre des innern Erdkœrpers,* 1837, p. 443 to 505.)

§ The experiments of Sir James Hall on the consolidation of basalts and melted rocks, date 1800.—(*Edinburg Phil. Trans.,* vols. v and vi.)

‖ The experiments of Hall were continued on a larger scale by Gregory Watt.—(*London Phil. Trans.,* 1804, and *Bibliothèque Britannique,* No. 256.) At the same time Dartigues published his experiments on the devitrification of glass.—(*Journal de Pharmacie,* lix; *Journal de Physique,* lx; *Annales de Chimie,* vol. l.) Fleuriau de Bellevue, sur l'action de feu dans les volcans, lx, 1805. Drée. Nouveau gendre de liquéfaction ignée —(*Journal des Mines,* vol. xxiv, 1805; *Mémoires de l'Académie des Sciences,* 1805; *Mémoires de l'Académie,* 1739; *London Philosophical Transactions,* 1776 and 1782)

Recent observations on devitrifications by Dumas and Pelouze, (*Comptes Rendus,* 1845, 1855, 1856,) and by Messrs. Mitscherlich, Gustave Rose, Charles Deville, and Delesse on the fusion of rocks.

§ 2. *Examination of crystals accidentally obtained in metallurgical manufactures.*

It was thus that the examination of the silicates which flow in abundance in a state of fusion from metallurgical furnaces, was naturally suggested. In accordance with the idea of Leibnitz, Professor Haussmann, in 1816, availed himself of this kind of observation in order to explain geological phenomena, and since that time, this veteran of science has not ceased to render it important tributes.* Soon after Mitscherlich discovered that peridot, pyroxene, and other mineral species crystallize accidentally in the slags of manufactories.† It was a worthy complement of his work on the relation between the forms of crystals and their chemical composition, which had just made such a brilliant mark in mineralogy and chemistry. Since then, under this interesting point of view, metallurgical scoria has been examined with care by Berthier, Vivian, Bredberg, Sefström, Zinken, Wœhler, Karsten, Plattner, Rammelsberg, F. Sanderson, Percy, Miller, and other savants. Professor de Leonhard has recently published a work on this subject in which all the known facts relating to it are carefully summed up and compared.‡

The products obtained in manufactories by the crytallization or liquation of melted matters, are not the only ones that are of a nature to interest the geologist. There are some, such as galena, oxide of zinc, blende, which separate themselves from furnaces either by direct sublimation, or by the volitilization of a part or of the whole of their elements. Among these results of condensation, the most remarkable is feldspar, which has at different times been collected in the upper part of the copper furnaces of Mansfield, in the sublimations of zinc furnaces, the presence of which, simply suspected at first, was proved beyond a doubt by the examinations of Heine and the analysis of Karsten.§ The formation of this important mineral by means of vapor, merits so much the more attention, because, notwithstanding many attempts, it has never yet been obtained crystallized by a direct fusion.

§ 3. *Synthetical experiments by simple fusion or by different mixtures.*

The inspection of crystals, which are accidentally formed in manufactories, necessarily led to direct experiments in the dry way by different methods.‖ It is to Berthier that we owe the first attempts in this interesting direction.

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* *Göttingsche gel. Anzeigen*, 1816, p. 489.—This first memoir was followed by others, both numerous and important, on the same subject.

Koch, in 1809, had described some crystals of the manufactories, among others, the oxide of zinc. The graphite which separates itself from cast iron had also been long remarked.

† *Abhandlungen der k. Akademie der Wissenchaften zur Berlin*, 1823, p. 25.—*Annales de Chimie et de Physique*, vol. xxiv, p. 355.

‡ Dr. Gurtlt. *Pyrogennete künstliche Mineralien*, 1857.—Von Leonhard, *Huttenerzeugnisse*, 1858. Idocrase, gehelenite, are among the most frequent products.

§ *Poggendorff's Annalen*, vols. xxxiii, p. 336, and vol. xxxiv, p. 531.

‖ Attempts have been made to facilitate the crystallization of different substances by acting upon large masses, which cool very gradually, and by blowing gas into them with a view to producing geodes.

By melting silica with different bases in definite proportions, he obtained in 1823 crystalline combinations identical with those of nature; especially pyroxine.* Afterwards, Ebelmen succeeded, by a very ingenious process due to him, in obtaining infusible combinations. This process consists in employing solvents in a state of fusion, and which can be vaporized slowly at very high temperatures, such as boracic acid, and the alkaline phosphates, or carbonates. It is thus that he produced corundum, the different kinds of spinel, cymophane, peridot, perowskite, and other species.†

The mutual reaction at high temperatures of the volatile metallic fluorides and oxygen compounds constitutes a process which has lately furnished to its authors, Henri Deville and Caron, very beautiful reproductions of infusible minerals, such as corundum, colored in different ways, and staurotide.‡ The same chemists have invented a different process for reproducing apatite.§ It is likewise by a partial volatilization that M. Gaudin has obtained artificial ruby by melting at a very high temperature a mixture of alum and sulphate of potash.‖ Despretz has announced that he has obtained the diamond by different processes based upon the transposition and slow deposition of carbon by the electric current.¶ By melting certain mixtures of salts and treating the residue with water, M. Manross has imitated sulphate of baryta, apatite, wolfram, and other minerals.** Rock salt alone employed as a flux has sufficed Forchhammer for producing crystallized apatite, operating, as he did, even on rocks which contained only traces of phosphates.†† If we reflect on the enormous amount of chloride of sodium contained in the liquid envelope of the globe, we can hardly doubt that this salt has co-operated in the crystallization of certain species, especially at the time when the water was not yet entirely condensed. Charles Deville has recently made experiments in this direction, by heating clay or a quartz sandstone previously moistened with chloride of sodium.‡‡

Sec. 4. *Synthetical experiments by the aid of vapors reacting mutually or on fixed bodies.*

Some minerals may be imitated by simple sublimation; such are arsenic, galena, and senarmontite.§§ But it is especially by causing certain vapors to react among themselves, as in metallurgical manu-

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* *Annales de Chimie et de Physique*, vol. xxiv, p. 365, 1823.

† *Annales de Chimie et de Physique*, vol. xxii, p. 221, and vol. xxv, p. 279.—*Annales des Mines*, 5th series, vol. ii, p. 349.

‡ *Comptes Rendus de l'Académie des Sciences*, vol. xlvi, 1858, p. 765.

§ Apatite and wagnerite have been obtained by a kind of distillation of the phosphates in the chlorides of the same metals.—(*Comptes Rendus*, vol. lxvii, p. 985, 1858.)

‖ *Comptes Rendus*, vol. xlvi, p. 765, 1857.—The melted alumina in the form of ruby, previously obtained by this author, was amorphous, vol. v, p. 803, 1837.

¶ *Comptes Rendus*, vol. xxxvii, p. 369, 1853.

** *Annalen der Chemie und Pharmacie*, vol. lxxxii, p. 348, 1852.

†† *Poggendorff's Annalen*, vol. lxxxi, p. 568, 1854. Forchhammer has even proposed this method for detecting phosphates and certain metals in rocks, when by the ordinary processes only slight traces are found.

‡‡ *Comptes Rendus de l'Académie*, vol. xlvii, p. 80, 1838.

§§ *Annales des Mines*, 5th series, vol. i.

factories, that various results can be arrived at. It is thus that Gay Lussac obtained peroxide of iron crystallized like natural specular iron, by decomposing at a high temperature perchloride of iron by means of the vapor of water. This reaction sometimes takes place, as M. Mitscherlich discovered, in the pottery furnaces into which chloride of sodium is thrown.* I myself tried, in 1849, a reaction founded on the same principle, in order to verify, experimentally, the action which, on purely geological observations, I had previously attributed to veins of tin ores. By the decomposition of the bichlorides of tin and titanium, I obtained the crystallized oxide of tin, having the same lustre and hardness as the natural mineral, but isomorphous, with the oxide of titanium known under the name of brookite; I have also produced this last mineral itself.† By bringing sulphuretted hydrogen to act on different metallic chlorides reduced to a state of vapor, Durocher has obtained some of the principal sulphurets contained in metallic veins, such as grey copper.‡

Instead of causing the vapors to act one on another, they can be used to attack fixed substances, and thus to develope new combinations. It was upon this principle that I first artificially obtained apatite, as well as topaz.§ Still later I produced, by means of the chlorides of silicium and of aluminium, crystallized silicates and aluminates.‖ I also imitated the red oxide of manganese or hausmannite.¶ Mention ought also to be made here of the production of dolomite by Durocher, by the action of chlorine and magnesian vapors on limestone;** of the experiments of Charles Deville on the alteration of silicious rocks by sulphuretted hydrogen and water;†† as well as of those of Rogers on the manner in which water charged with carbonic acid decomposes, even in the cold, the principal natural silicates. It has been said that the vapor of water, if it is at a high temperature, is sufficient to attack numerous silicates.‡‡ Thus, according to M. Jeffreys, bricks heated to the temperature of the fusion of cast iron give off, to a current of the vapor of water, silica, which is condensed in the form of snow.§§ It is by a similar action that water corrodes enamels in the porcelain furnaces.‖‖

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* *Poggendorff's Annalen*, vol. xv, p. 630.—M. Nöggerath has also noticed it as the result of a fire in a salt mine of Wieliczka. The furnaces in which carbonate of soda is manufactured at Framont in the Vosges, by decomposing the chloride of sodium by iron pyrites, have produced splendid coatings of specular iron on the surface of the bricks.

† Researches on the artificial production of some crystallized minerals, particularly the oxides of tin and titanium, and of quartz.—(*Observations sur l'origine des filons titanifères des Alpes; Annales des Mines*, 4th series, vol. xvi, 1849.)

‡ *Comptes Rendus*, vol. xxxii, p. 823.

§ *Annales des Mines*, 4th series, vol. xix, p. 669, 1851.

‖ *Comptes Rendus*, vol. xxxix, p. 135, 1854.

¶ *Annales des Mines*, 5th series, vol. i, 1852.

** *Comptes Rendus*, vol. xxxiii, p. 64, 1851.

†† *Comptes Rendus*, vol. xxxv, p. 261, 1852.

‡‡ *Annales des Mines*, 3d series, vol. vii, p. 448, 1835.

§§ Jeffreys's Report of the British Association, 1840.—(*Bibliothèque Britannique*, vol. viii, p. 441.)

‖‖ Alex. Brongniart and Regnault have verified this fact at Sèvres.

§ 5.—*Humid process.*

The action of the vapor of water on the chlorides and on the silicates, which has just been noticed, is, as it were, an intermediate one between the dry and the wet way. It remains for us to sum up the results of this last. Bequerel has long ago shown the influence of slow action, aided by electricity of very feeble tension, in precipitating insoluble combinations which imitate those of nature.* It was also by the slow decomposition of silicic ether that Ebelmen produced a hydrated silica in solid, compact masses, similar to hyalite and hydrophane.† Gustave Rose has skilfully analyzed the conditions under which carbonate of lime is precipitated in the state of arragonite. Bischof and Sterry Hunt have made divers experiments, the first to verify his ideas on the formation of minerals, the second in support of his theory of the origin of magnesian rocks.‡ Charles Deville has examined how it is that water, with the sole aid of carbonic acid, and without the help of pressure, can contribute to the formation of dolomites.§ From reactions which are produced in the manufacture of hydraulic limes and cements, Kuhlmann has deduced interesting results for geology.‖ Mention may here be made of the action of the alkalies on rocks, by Delesse.¶ It is especially at high temperatures and under pressure that we succeed in imitating mineral substances in water.

Hall** and Cagniard-Latour†† long ago discovered that vegetables in these conditions are affected in a peculiar manner. By submitting wood in water to a temperature of about 300° centigrade, I produced a real anthracite.‡‡ At a lower temperature Baroulier, by means of vegetables enclosed in moist clay, obtained an imitation of coal.§§

The beautiful experiment of Haidinger and Morlot on the formation of dolomite has inaugurated the use of water under pressure for the formation of minerals.‖‖ Instead of forming dolomite by the reaction of sulphate of magnesia on carbonate of lime, Favre and Marignac have since used the chloride of magnesium to produce the same effect.¶¶

De Senarmont has undertaken a long series of experiments,

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* *Annales de Chimie et de Physique*, vol. xxxii, p. 244, 1823.

† *Annales des Mines*, 4th series, vol. viii, p. 149; *Comptes Rendus*, vol. xxi, p. 527; *Leonhard's Jarbuch*, p. 807, 1858.

‡ *Bibliothèque de Genève*, 1857, p. 268.

§ *Comptes Rendus*, vol. xlvii, p. 90, 1858.

‖ *Comptes Rendus*, vol. xii, p. 852; vol. xxxv, p. 739.

¶ *Bulletin de la Societié Géologique*, 2d series, vol. xi, p. 127.

** Hall obtained a kind of coal by the dry way.

†† *Comptes Rendus*, vol. xxxii, p. 275, 1857.

‡‡ *Annales des Mines*, 5th series, vol. xii, p. 305, 1857.

§§ *Comptes Rendus*, vol. xlvi, p. 376, 1858.

‖‖ *Mémoires de l'Académie de Vienne*, vol. 1, p. 305, 1847.

¶¶ *Bibliothèque de Genève*, May, 1849.

which have thrown much light on very important phenomena.* Operating with the aid of water at a temperature of 130° to 300° centigrade, he succeeded in producing, in a crystallized state, the principal minerals which characterize metallic veins—among others, quartz,† spathic iron, the carbonates of manganese and zinc, sulphate of baryta, sulphide of antimony, mispickel, and red silver. To comprehend at this time all the importance of the problem which was thus solved by this savant, we must remember that until then we had not been able to imitate the greater part of the minerals occuring in veins. Now, the most characteristic species of these formations, numbering more than thirty, have been reproduced by a process similar to that which observation led us to suppose, and by the aid of the element the most widely distributed in hot springs. This memorable achievement, for the first time, showed in geology that an induction relative to an entire order of facts may be demonstrated by experimental synthesis.

De Senarmont has also shown that the sole action of water suffices, with the aid of a high temperature, to isolate the bases of certain salts. It is thus that anhydrous oxide of iron and crystallized alumina or corundum have been produced by the decomposition of solutions of chloride of iron and chloride of aluminium. Brochantite (sub-sulphate of copper) and azurite have been recently obtained by the same process. Up to that time the humid way had not served to produce anhydrous silicates. I have been able to do this by a series of experiments, the principal results of which I shall give in the third part.‡

We may add that nature herself continues to make daily experiments (if the expression may be used) of the same kind with those which we only perform with so much difficulty, employing probably processes analogous to those which she has resorted to from the most remote ages. Unfortunately these reactions take place in regions that we can very rarely reach. It is only in a very few instances that we can be witnesses of the formation of contemporaneous minerals. It is sufficient to go down a few yards into the subsoil of Plombieres, and to enter the masses infiltrated for centuries by thermal waters to discover sulphuret of copper in crystals identical with those of Cornwall, and a whole series of zeolites, arranged as in basaltic rocks.§ What would be the result if we could penetrate deeper into the ducts through which these hot springs ascend?

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* Expériences sur la formation artificielle par voie humide de quelques espèces minérales qui ont pu se former dans les sources thermales sous l'action combinée de la chaleur et de la pression.—(*Annales de Chimie et de Physique*, vol. xxviii, p. 693, 1849.) Expériences sur la formation des minéraux par voie humide dans les gîtes métallifères concrétionnes.—(*Annales de Chimie et la Physique*, vol. xxxii, 1851.)

† *Anzeigen*, p. 557, 1845.

‡ Observations sur le métamorphisme et recherches expérimentales sur quelques-uns des agents qui ont pu le produire.—(*Annales des Mines*, 5th series, vol. xii, p. 289, 1857; *Bulletin de la Sociétié Géologique de France*, 2d series, vol. xv, p. 97.)

§ Memoire sur la relation des sources thermales de Plombieres avec les filons métallifères et sur la formation contemporaine des zéolites.—(*Annales des Mines*, 5th series, vol. xiii, p. 227.) The formation of iron pyrites, which is a mineral so widely dispersed, has been but very seldom seen; and first by Longchamp at Chaudesaigues. Bischof met with it at Brohl, and Bunsen in Iceland.

When we can succeed in thus taking nature by surprise, after the first emotion of pleasure at having wrested from her one of her secrets, we experience a feeling of humility in seeing at the cost of what difficulties we are able to reproduce a few of the most simple mineralogical formations; yet the results already attained show that we have no reason to be discouraged, and that we have it in our power to imitate no small number of minerals without the intervention of centuries.

SECOND PART.

EXPOSITION OF THE FACTS WHICH CONJOINTLY CONSTITUTE METAMORPHISM.

The variety of the facts which I have to present induces me to group them in five chapters. I shall first examine *metamorphism of juxtapositiom;* secondly, *regional metamorphism.* I shall then pass in review *metamorphism of structure*; then the phenomena relating to the deposits of *dolomite, rock salt, sulphur, and bituminous deposits;* finally, the *general relation of metalliferous deposits and thermal springs to metamorphism.*

The observations relating to *primitive gneiss*, the origin of which is doubtful, will be reserved for the third part, which will terminate this memoir.

This exposition will be very brief; for it has for its object well-known facts, which it is only necessary to recall in order that we bear in mind the conditions which the theoretical explanation ought to satisfy.*

FIRST CHAPTER.

METAMORPHISM OF JUXTAPOSITION. †

When a rock has been thrown up from below, the beds which it traverses have generally been modified in its neighborhood. Sometimes this modification of the enclosing rocks is reduced to a very narrow bordering, of a few sixteenths of an inch, and the changes produced upon this thin layer are not very decided.‡ In others,

* The examples known would form an entire treatise on descriptive geology. I shall not give them in detail, but content myself with simply announcing them. I shall refer for details to the best works on general geology, particularly to those of Naumann, Studer and Lyell.

† It seems best to me to use this denomination rather than that of metamorphism of *contact*, which is ordinarily employed, because the modifications which it explains extend far beyond the contact of the rocks. The word *local* does not appear to me to be sufficiently characteristic.

‡ As an example, I will confine myself to citing many veins of basalt which intersect the jurassic formation of the Wurtemberg Alps. Granite itself has not always modified the schist, even when it was in a sufficiently fluid state to be injected into it in veins, as in the Vosges near Wesserling.—(*Bulletin de la Société Géologique*, vol. iv, p. 1446.)

and particularly when the eruptive rock is of a granitic nature, the extent of the modified zone, as well as the more complete changes that have taken place, denote a much more energetic action.

Not only the extent of the modified zone varies according to the nature of the eruptive rock, but for the same rock, and in the same country, this extent presents great differences.* Near the granite it is often of some hundred yards, and, exceptionally, even 3,000 yards: for instance, in the environs of Christiania this band is on an average 360 yards; in the Pyrenees it attains 1,500 yards, perfectly characterized in its effects.† In general, it is remarked that the transformation has extended further between the re-entering angles formed by the eruptive rock than opposite the salient parts.—(Champ-du-Feu in the Vosges,‡ environs of Christiania.) With regard to the nature of the modifications undergone by the surrounding rocks, they are so various that it is difficult to give a summary of them.§

Sometimes only a new molecular arrangement has taken place; limestone has become saccharoidal like statuary marble; elsewhere sandstone has been changed into quartzite.—(Isle of Sky.) The mineral combustibles have generally been modified by losing a part of their constitutive elements.‖ It is thus that lignite has been changed into coal, into anthracite, and sometimes even into graphite, (graphite mined in the tertiary formation at Omenatk, in Greenland, in which formation it is also known in Java.) Coal has sometimes been changed into one of these two last states, (graphite of Scotland, graphite and anthracite of Worcester, Massachusetts.) More rarely coal and lignite have been transformed into a kind of coke.¶ Bitumen, accidentally isolated from these combustibles, has been lodged in the rocks which were more or less near.—(Lobsann, in the Bas-Rhine, Hering, in Tyrol.) Most frequently new crystalline combinations have been developed, either with the pre-existing elements of the rock, or by the aid of new elements which have been introduced, or by the elimination of some of those which were originally there.**

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* The chalk of the northwest of Ireland, near certain veins of trap, is not modified in the least; it has, on the contrary, become crystalline near those that are very large; in this last case the modification rarely extends beyond three yards. The same rock forms veins in the Isle of Sky, in Scotland; near some of them the lias is modified, whilst it is not at all affected near others, nor are we able to account for the cause of this difference.—(*Karsten's Archiv.*, vol. 1, 2d series, p. 99.) The rocks of the transition formations of the Vosges, into which granite has penetrated in veins, presents still greater differences; sometimes the modification is imperceptible, as in the valley of Wesserling; sometimes it is very distinctly marked, as at Andlau and at Barr.

† Durocher, memoir cited above.

‡ The transition formation is modified in a manner much more complete and over a greater expanse at the top of the valley of Barr than in the valleys of Villé and d'Andlau; and this appears to result from the fact that, instead of simply bordering on the granite, it forms in the first locality a long band, which is as it were let in between the granite and the syenite.—(*Description Geologique du Bas Rhin*, p. 54.)

§ *Annales des Mines*, 5th series, vol. xii, p. 89.

‖ Which does not prevent them from often having acquired new minerals like the other rocks, as the zeoliths, for instance.

¶ This last transformation, pointed out near Newcastle, for instance, has not as yet been observed in the proximity of granitic rocks.

** It is this last that appears to have happened in the granular quartz of Brazil.

Among the minerals which are most frequently formed in argillaceous schists are macle, or chiostalite, staurotide, disthene, mica belonging to two species, which is often in very small spangles; the feldspars, orthose, and anorthite; amphibole, which is sometimes sufficiently abundant to constitute an amphibolic schist,* tourmaline,† &c. These minerals are generally found in the neighborhood of granite. It is chiefly in limestone that a great variety of minerals have been found, among which I will mention garnet, idocrase, amphibole, wollastonite, epidote, paranthine, dipyre, couzeranite, magnesian mica, gehlenite, chondrodite, spinel,‡ serpentine, talc, chlorite, seladonite, the zeolites, certain clays, &c. These different minerals do not, however, belong exclusively to calcareous rocks.§ Thus the zeolites are found not only in limestones, but also in argillaceous rocks, sandstones, and sometimes even in mineral combustibles, when these rocks have been traversed by eruptions of trap.‖ In the neighborhood of all kinds of eruptive rocks, granite and others, quartz is often accumulated, either in crystalline or compact masses, or as jasper.¶ This ubiquity belongs, also, to other minerals of metallic veins, such as the carbonates with lime, magnesia, and iron, as bases, sulphate of baryta, fluor spar, and specular iron.** As examples of this action, the varieties of which are numberless, I mention the classic locality of the Hartz, where the schist that borders on the granite (hornfels) contains mica, feldspar, tourmaline, chlorite, garnet;†† Cornwall, where effects of the same kind are produced;‡‡ the Vosges,§§ the Pyrenees, Britanny,‖‖ Norway, &c.

Sometimes the rocks bordering on granite or syenite are modified to such an extent that they themselves assume the character of eruptive rocks. Thus, in the Vosges, argillaceous schist passes by insensible gradations to a feldspathic rock, which is sometimes porphyroidal, and to green porphyries studded with anorthite and amphibole. Similar facts have been observed in other countries.¶¶ The transformed rock often becomes amygdaloidal; in certain parts of Ger-

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* Environs of Christiania.

† Hornfels in the Hartz.

‡ Monzoni, Somma; the silurian limestone of Sparta, in the United States.

§ Some, however, as wollastonite and gehlenite, have as yet only been found in limestone.

‖ Tertiary limestone of the conglomerate of Puy de la Piquette, marls of the Cyclops islands, containing beautiful crystals of analcime, argillaceous schists of Andreasberg, in the Hartz, and of the Isle of Anglesey, tertiary sandstone of a vitrified appearance in Wildenstein, in Veteravia. Zeolites have even been formed in granite, near veins of basalt which traverse it, in the Isle of Arran, for instance.—(Boué —*Essai Geologique sur l' Ecosse*, p. 499; and at Haustein, in the Forêt-Noire; (Schill, *Neues Jarbuch*, 1857, p. 36.)

¶ Tuscany, Greece, Ural, &c.

** Sometimes quartz has been simply isolated by the decomposition of pre-existing silicates, as we shall see in the third part; sometimes it results, as in the other gangues of metalliferous veins, from a manifest *deposit*.

†† According to Hoffman and Zincken.

‡‡ De la Beche.—(*Geological Report on Cornwall*, p. 267.)

§§ Daubreé.—(*Description Géologique du Bas Rhin*, pp. 32 and 52.)

‖‖ According to the pre-cited memoirs of Palassou, Dufrénoy, and of Durocher.

¶¶ *Bulletin de la Société Géologique*, 1st series, vol. vii; *Comptes Rendus*, vol. xix, p. 857; *Reisnach Oural*, vol. ii, p. 185.

many it there bears the name of schaalstein.* We know, moreover, that the eruptive rock itself often undergoes modifications in the neighborhood of the enclosing rocks.†

The different transformations which I have been noticing form, so to speak, irregular aureoles around granite and the other eruptive rocks. Elie de Beaumont has shown that, according as the rock is acid, that is, contains an excess of silicic acid or basic, the metalliferous deposits in connexion with it present two distinct types. The same is true of the metamorphic aureoles of which I have just spoken, and the observations of Delesse have contributed to prove it. Thus, on the one hand, the zeolites which have so often been found near trap rocks have not been found near effusions of granite.‡ On the other hand, this last rock produces certain minerals, to the exclusion of all others, such as, for instance, the aluminous silicates, known under the name of macle and staurotide, so common in the argillaceous schists of Britanny. Micaceous and feldspathic schists very frequently envelop granite to a great depth in the Pyrenees and elsewhere; we do not know of anything analogous near the traps.

CHAPTER II.

REGIONAL METAMORPHISM.§

I repeat that I am speaking here of the schistose masses whose metamorphic origin is clearly proved; consequently I refer to the third part of this memoir, the examination of primitive gneiss, mica schists, and other subordinate rocks, which are inferior to the stratified fossiliferous formations. Considerable masses of stratified rocks, occupying entire counties, often exhibit very marked traces of metamorphism, even when it is impossible in these formations to discover the least outcrop of eruptive rocks.‖ This modification is easily verified in countries where it has been of so feeble an intensity as not to have entirely destroyed the sedimentary character of the rock; such are Wales, the Taunas, and the Ardennes. In the silurian and devonian periods of this last locality the rocks have in part become schistose, and over

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* These amygdaloidal rocks frequently pass to fossiliferous limestones, and often themselves take the form of a conglomerate. (Steingraben, in the Vosges, Nassau, county of Brilon in Westphalia, where they are associated with a Labradoric porphyry; Paimpol, in Britany, Lake Superior, and Nova Scotia) Certain spilites of the Alps and of l'Esterel are considered as metamorphic by Mr. Gras.

† Whence the name of *endomorphism*, proposed by Fournet; often, according to Delesse, it is impregnated with a magnesian hydrosilicate.

‡ Durocher; memoir cited above, p. 607 and 614.

§ The name of regional metamorphism, which I have proposed, appears to me more exact than *normal* metamorphism, and less vague than that of *general* metamorphism.

‖ The difference in the nature of mineral combustibles, lignite, coal, anthracite, which varies according to the formation, may be considered as an example of a metamorphism that has taken place without the intervention of eruptive rocks; it has acted, perhaps, on more impressionable substances than rocks. It is on this account that anthracite only is found in the Alps and in the talcose schists of the Basse-Loire, and that the eocene formation of Tuscany contains a real coal.—(*Monte Bamboli.*)

a great extent chlorite, in innumerable microscopic crystals,* has been formed between their lamellæ; feldspar has also sometimes been introduced; furthermore, a multitude of quartz veins, some parallel to the lamellæ and others oblique, have been isolated within them, and these veins themselves often contain the minerals which have just been cited; lastly, sandstones have been changed into quartzites.† Now we can hardly admit that stratified and fossiliferous formations could have originally possessed those mineralogical characters, and hence it is conceded by all that they owe their present nature to a transformation undergone since their deposition.

But when the same phenomenon presents itself under a more advanced phase, it needs a more attentive examination to authenticate it, nor is it always possible to attain a certainty, because the primitive type has been more or less completely effaced by chemical action posterior to the formation of the sedimentary rock. Thus, in the immense masses of crystalline rock of the Alps, we find, as in the Ardennes, a chlorite schist with veins of quartz and often of chlorite, but it is in general more perfectly crystallized. (Zillerthal, in Tyrol, Salsbourg.) It is associated with a series of other crystalline rocks, of various natures, which alternate irregularly among themselves, especially talcose schist, green schist,‡ amphibolic schists, and even some schistose diorites,§ talcose gneiss, (described by Saussure under the name of veined granite,) quartzite,‖ calcareous and often micaceous schists, more rarely dolomites and gypsum, also studded with a variety of minerals. (Environs of Airolo.)¶ Yet, notwithstanding the peculiarly crystalline character of the rock, the greater part of the geologists who have described the Alps have considered them as of sedimentary origin.

The conclusion that certain crystalline and very extended formations, such as those of the Alps, are metamorphic, rests upon many evidences which are, however, very nearly of the same order with those which prove the metamorphism that has taken place in the neighborhood of eruptive rocks. I mention the following:

1. The analogy of composition which unites certain groups of crystalline with sedimentary rocks is at this day still striking, notwithstanding the modifications which the first appear to have undergone. We find, in effect, as in the sedimentary rocks, beds of limestone,

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* M. Sauvage discovered by analysis the existence of chlorite, even in those varieties of phyllades where the naked eye cannot distinguish it. It is under these same conditions that sericite is found in the schists of Taunus.

† *Explication de la Carte Géologique de France*, vol. i, p. 77. Durocher; memoir cited above, p. 603.

‡ The rocks named *green schists* by Mr. Studre, and which are certainly metamorphic, have been recently carefully examined by Mr. Rath. They are of a very variable composition, and often contain aligoclase and albite.—(*Zeitschrift der Deutsch. Geol. Gesellschaft*, vol. ix, p. 211.)

§ We have before mentioned that the schistose diorites of the Ural are generally considered as metamorphic.

‖ *Transactions of the Geological Society of London*, 1st series, vol. iv, p. 264; 2d series, vol. i, p. 53; *Cosmos*, vol. i, p. 305.

¶ Serpentine itself, in certain of its formations in the Alps, the Ural, the Alleghanies, and elsewhere, appears to result from the metamorphism of different amphibolic and other rocks, as numerous observations prove.

of dolomite, of gypsum, of a quartzose rock or quartzite, in fine chloritic and talcose schists, which it would often be impossible to distinguish from rocks of the same character, belonging to a well-characterized silurian formation. I will also call to mind, as Bischof has observed, that the elementary composition of certain argillaceous schists of the transition formations is often very perceptibly the same as that of granite and of gneiss.

2. The same country will present instances of the passage, unquestionably gradual, of crystalline into stratified fossiliferous rocks. These insensible transitions, which prevent the establishment of a line of demarcation between these two categories of rocks, and that suggested to Werner the name of *formation of transition*, (Uebergangsgebirge,) which he gave to the group in which they occur most frequently, have been too often described to make it necessary to enlarge on this subject*. There are localities, however, especially in the Alps, where crystalline rocks are inserted in the midst of sedimentary rocks, which are but slightly modified.

3. We know that the crystallization which has taken place in proximity to eruptive rocks has not always effaced the trace of fossils. Distinct vestiges of them still exist in the midst of rocks studded with crystalline silicates. It is sufficient to cite the fossiliferous silurian limestone of Norway, which at Brevig contains paranthine and garnet, and at Gjellebeck amphibole with epidote, the jurassic limestone of Angoumert, in the Ariege, containing dipyre; the schists of Britanny, so well described by M. Boblaye, of which the same specimens contain macles of several sixteenths of an inch in length, with orthis, spiriferes, and calymenes; the white sub-crystalline limestone containing encrinites, discovered in the Ural, on the borders of the river Miask, by Murchison and de Verneuil, in the midst of a region of granite, serpentine, and metamorphic rocks;† in fine, the amphibolic rock of Rothau, in the Vosges, in which polyps, without changing their form, have been replaced by crystals of amphibole, garnet, and axinite.‡ The same thing occurs in the masses of crystalline formations which we are now considering. Since the instance cited by Brochant: De Charpentier, Lardy, and Studer, have discovered in the neighborhood of St. Gothard belemnites in the midst of a micaceous schist containing garnet.§ The possibility of a transformation appears, however, proved by the blocks

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* Among the numerous examples that we could cite, it will be sufficient to mention Britanny, (*Explication de la Carte Géologique de France*, vol. i, p. 234 ;) Saxony, where these transitions have been remarkably well described by Naumann ; the Alps of Dauphiny, of the Tarentaise, of Switzerland, of Tyrol, of Saltzbourg, of Carinthia, according to Brochant, Elie de Beaumont, Sismonda, Gras, Lory, Studer, Escher, Lardy, Favre, Murchisson, Credner, and many others ; the Ural, according to Murchisson and G. Rose, and the United States, according to Lyell.

The green schists in the different parts of the Alps (Grisons, Piedmont, &c.) form the passage between rocks evidently sedimentary and those that are crystalline.—(*Studer, Physikalische Geographie*, vol. i, p. 148.)

† *Russia in Europe and the Ural Mountains*, vol. i, p. 420.

‡ *Annales des Mines*, 5th series, vol. xii, p. 318.

§ Particularly at the Col de la Nufenen, near Airolo. M. de Charpentier, as long ago as 1822, found belemnites in the supposed primitive limestones of the Col de Seigne.—(*Cosmos*, vol. i, p. 541.)

which come from Mount Somma, where there is every description of transition, from the compact limestone of the Apennines, containing pectunculus, to the lamellar limestones and to dolomites, filled with crystallized silicates.

4. In rocks in which the crystalline state is still more distinctly marked, where no traces of animal forms are any longer to be seen, the remains of plants are sometimes preserved. We find, for instance, vegetable imprints in feldspathic and micaceous rocks, which are so crystalline that they might be mistaken for eruptive rocks, especially if they were to be determined by isolated specimens. Such are the feldspathised grauwacks of Thann, the schists of Bussang, in the Vosges, the *pierre carrée* of the banks of the Loire, which is frequently associated with anthracite, rocks which are assigned to the carboniferous or anthracite formation.

5. When the forms of the vegetables themselves are no longer found, these schistose crystalline rocks often contain carbonaceous compounds which, in all probability, are of organic origin. It is thus that the micaceous schists of Ariolo, which are studded with garnets and long prisms of amphibole, still contain, according to an assay that I made of them, as much as 5 per cent. of carbon;* the same is true of many slaty schists†.

It follows, from what precedes, that it would be difficult to establish a distinction between metamorphism of juxtaposition and regional metamorphism, if we were to judge by mineralogical characters only; the two phenomena differ principally in the extent of their action. It is chiefly in the lower beds of the series of stratified formations that the effects of regional metamorphism are remarkable.

A splendid example of the transformation of the palæozoic formations occurs in the Ural; the sedimentary origin, and the age of the crystalline schists which compose it, have been placed beyond question by the admirable work of Murchison, De Verneuil, and Keyserling.‡ The very feebly consolidated silurian formations of Russia, in these mountains are transformed into crystalline schists, which have here and there preserved, as if to prove their origin, strips of fossiliferous rocks. The same is true of the carboniferous formation. The white and soft limestones of Moscow are found in the Ural with the same fossils (*Productus gigas* and *Spirifer mosquensis*,) but under the form of a hard, dark, and crystalline limestone. Regional metamorphism, however, is not exclusively confined to the primitive formations, and, on the other hand, it does not, of necessity, belong to them. Thus, on the one side, we find schists that have become crystalline as high up as the beds containing belemnites, and even in the nummulitic formation, (as in the Grisons.§) On the other

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* After having removed the carbonate of lime by an acid, the carbon was determined by the oxide of copper, as in organic analyses.

† It is very possible that the bituminous matter found by M. Delesse in the protogine of Mount Blanc is of organic origin.

‡ *Russia*, vol. i, pp. 402, 438, and 465.

§ According to Sir R. Murchison, these rocks are allied to gneiss.—(*Geological Quarterly Journal*, vol. v, p. 211, 1848.)

hand, some silurian formations are hardly modified at all, even in their inferior beds, as we see in Russia, Sweden, and in the United States.*

The remarkably crystalline state of many palæozoic formations should not, then, be exclusively attributed, as has been supposed, to a certain peculiar position in which the earth was at the time of their deposition, but in reality to peculiar agencies which have affected certain regions in preference to others.

CHAPTER III.

METAMORPHISM OF STRUCTURE.

Many masses of rock can be more or less perfectly divided into parallel lamellæ.† These lamellæ are not caused by a cleavage of crystallization, nor are they owing to stratification. The plane of the lamellæ is frequently oblique to that of the beds. There are countries, however, where the transversal disposition is exceptional, and where the lamellæ are generally parallel to the stratification.‡

This lamellar structure is particularly developed in argilaceous schists or phyllades, but it is not exclusively peculiar to them; it belongs to rocks of different natures, such as quartzites, sandstones, limestones, especially when they are impure. Different circumstances show that lamellar rocks have undergone mechanical action, particularly energetic pressure, which has produced upon them indelible effects. The greater part of the fossils which they contain have been compressed and drawn out in a very characteristic manner. It is to the slips which have resulted from this pressure that the lamellar structure appears to owe its origin, as is confirmed by the experiment which we shall presently cite.

Certain peculiarities of structure, less marked than the cleavage, result likewise, without doubt, from mechanical action. Such are the *secondary joints*, known to those who work slate;§ the fibrous structure which results as if from a folding of the lamellæ;‖ the structure called pseudo-regular, which occurs frequently in quartzites and coal. These different methods of division are therefore to be also mentioned as a metamorphism of the kind we are describing. The abnormal schistose

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* According to the very recent observations of Sir R. Murchison, metamorphism has played a more important part than was suspected in the constitution of the silurian formation of Scotland.

† Often the joint is not more distinct in the rock before it is brought out by a shock than cleavage in crystals; it is, as it were, latent, as we see in the slate quarries.

‡ This habitual parallelism has been noticed in the Hartz, in Saxony, in Britanny, in Scotland, in Devonshire, and in the system of the Rhine, by Hausmann, Naumann, Durocher, Macculoch, De la Bèche, Baur, and De Dechen.

§ The chief of these secondary joints is called *longrain* by the quarrymen of the Ardennes.

‖ The bacillary structure of some limestones of the Alps, such as those of Klam, in the Tyrol, is an example of it.—(*Favre; Géologie du Tyrol Allemande; Bibliothèque de Genève*, 1849.) De la Bèche has given examples of these divisions in his *Geological Report of Cornwall*, p. 271.

structure, or, in other words, the lamellar structure, which does not owe its origin to stratification by deposition, although it is of frequent occurrence in the primitive formations, is not always found there, nor is it peculiar to them. On the one hand, we do not find real phyllades in the silurian formations of Sweden, of Russia, or of the United States, which have remained horizontal, and which have been mentioned above as in general not being metamorphosed. On the other hand, the schists suitable for being quarried as slates are found in the more recent formations which have been dislocated, as in the cretaceous formation of the Pyrenees and of Terra del Fuego,* and in the nummulite formation of Switzerland, in the environs of Glarus. Thus the origin of the lamellar structure, as of the metamorphic state, appears to be essentially connected with the existence of dislocations.

CHAPTER IV.

DOLOMITE, GYPSUM, ROCK-SALT, SULPHUR, AND BITUMINOUS DEPOSITS IN THEIR RELATIONS WITH METAMORPHISM.

We know that certain dolomites result from the transformation of limestone.† This epigeny may be explained, as the synthetical experiments which have been produced upon this subject tend to show, by the action of combinations of magnesia on carbonate of lime. There is, however, nothing to prove that this transformation into dolomite has always been produced by the same agents, and that the dolomite of Campo-Longo, for instance, with its tourmalines, its corundums, and its various minerals, is to be assimilated with the dolomite of the other parts of the Alps‡ and of Nice, or those which are near the deposits of calamine in Belgium.

But there are dolomites, and this is the case with the greatest number, situated in regular beds, which are often horizontal, constituting very extensive geognostic formations. When they contain remains of testaceous molusca the shell has disappeared; they are often crystalline and riddled with holes in such a way as to suggest a substitution. It is possible that the principal part of these last dolomites was directly precipitated.§ But on account of the disappearance of the shells we must admit, with Elie de Beaumont, that this second case allies itself with the first, by the reaction which the medium in which the precipitation has taken place, has exerted on the matter precipitated, a reaction of such kind that the carbonate

* According to Mr. Darwin.

† To the simple exposition of facts I will add in these three chapters a few theoretical considerations. This will exempt me from recurring to these phenomena in the third part.

‡ See especially the memoirs of Studer and his *Physikalische Geographie*, vol. i, p. 146.

§ *Annales de Chimie et de Physique*, vol. xxviii, p. 710; *Erdmann Jahrb. fur pract. Chem.*, vol. xlix, p. 52, 1850.

of lime has disappeared. Indeed, we notice that pure limestone never alternates with them.

Stratified dolomites are in general associated with deposits of anhydrite and gypsum, rocks which have been also considered as owing their origin to an epigeny;* they likewise frequently accompany deposits of rock-salt. These last three rocks, which have remarkable analogies in their modes of occurrence, have been, like dolomites, referred to two types of formation. Most frequently they are regularly subordinated to stratified formations, of which they constitute a characteristic element, as we see in the trias of western Europe and of Spain, and in the tertiary formations of the Carpathian mountains. Elsewhere there are casual deposits which appear to be directly connected with dislocations, as is admitted in regard to the beds of the Alps of Salzbourg and of Bavaria, of the Pyrenees, and of Algeria; thus the characteristic of a double origin attributed to dolomites is also found in the gypsums, anhydrites, and rock-salt which accompany them.

A very remarkable character of all formations containing salt, and which also shows the analogies and the singularity of their formation, is the uniform or variegated red tint of the clays, sandstones, and even of certain masses of the salt which compose them. I shall not be able here to reproduce the considerations by which Elie de Beaumont has compared these different connected facts, and has shown that in the mass of waters, which deposited the *marnes irisées*, phenomena analagous in their results to those which accompany volcanic action have taken place.† These red formations often cover perfectly regular beds, the coloration of which presents nothing abnormal; such are the *marnes irisées* which rest upon the muschelkalk. This circumstance, in connexion with the vast superficies which they often occupy, would seem to show that the heat of the earth had only exercised its action upon them in an indirect or circuitous manner, by heating the water of the sea. It would, therefore, perhaps be in virtue of a high heat and a chemical action with which the concentration of chloride of sodium was not unconnected, that the sea itself tinted the saliferous formations, thus leaving, as it were, a witness of a temperature which it had exceptionally experienced at certain epochs and in extensive portions of its basin.

We have just said that the regularly stratified dolomites are attributed to an epigeny of limestone, and that it was at the time of the deposit of this limestone and before it was protected by other depositions that this transformation had taken place; now, precisely

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* *Explication de la Carte Géologique de France*, vol. ii, p. 90.

† *Explication de la Carte Géologique de France*, vol. ii, p. 94.

De Senarmont has discovered that peroxide of iron may be dishydrated even in water, at a temperature between 160° and 180° centigrade. This reduction, in an experiment that I made, took place in a saturated solution of chloride of sodium at only 150°.

I also verified, by analysis, that the red part of the variegated clays not only differed from the green parts by the state of combination of the iron, but also by a very much greater proportion of the metal. This observation led me to imitate exactly the ordinary variegations of clays in passing successively vapors of chlorhydric acid and water over hot clay. Some parts of the clay became colorless, while other parts took a red tint at the expense of the first.

the same thing is true of some metalliferous deposits. The schists containing copper of Mansfeld, the formations of lenticular iron ore of the Voulte and of Privas, the beds containing jasper and metallic minerals of the environs of Nontron, have been formed, as M. Gruner remarks, anterior to all the beds which now cover them.* This kind of *immediate epigeny*, in the very water where these different deposits have been formed, appears then to constitute a common character with dolomites, with the reddish and variegated rocks, as well as with many metalliferous beds.

As another relation between these same formations I will further remark, that in strata of various ages metalliferous deposits are often associated with dolomite in such a peculiar way that there can be no doubt that there is a common bond of origin between these two kinds of deposits. We may cite as an example of this fact the masses of calamine overlying the carboniferous limestone of Vielle-Montagne and of Eifel;† those of San Juan de Alcarras and of the province of Santander, in Spain; the formations of the same metal in Silesia and Poland;‡ the dolomite containing zinc, of England; the small deposits of calamine of central France, such as Durfort, (Losère), Combecave, (Lot,) Alloue, (Charente;) the formations of galena of Alpujarras; the mass of iron ore of Vicdessos and of Canigou in the Pyrenees; the formations of the manganese of Nassau and those of Nontron, (Dordogne,) &c.§

Native sulphur, in its principal formations, is generally associated either by the relation of cause to effect or by the relation of effect to cause, with deposits of gypsum.‖ We see this in Sicily, in several parts of Italy, in the environs of Wieliczka in Poland,¶ in Teruel in Spain,** and on the banks of the Volga.†† If the sulphur came from below in the state of sulphuretted hydrogen, as in the solfatares and certain metalliferus deposits of Tuscany, where it is now daily being deposited on the wood-work in the galleries of the mines, and was there partially transformed into sulphate of lime by a more or less perfect combustion; or if the beds of sulphate of lime have undergone an interior reduction, and by a well-known reaction produced sulphur, under the influence of organic matters with which it is very often associated,‡‡ there is in either case a relation of metamorphism or

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* *Annales des Mines*, 4th series, vol. xviii, p. 91.

† Max Braun, *Zeitschr d. Deutschen Geologischen Gesellschaft*, Jarhrg, 1857; *Bulletin de la Société Géologique*, 2d series, vol. viii, p. 105.

‡ Memoirs of Karsten, De Carnall, and others on this interesting country.

§ We may include in this enumeration the beds of schist containing copper, of Mansfeld; the beds of sandstone, containing lead and copper, of the Moselle, which appear to have been formed, like those cited above, before all the beds which now cover them.

‖ Sometimes also with alunite, and less frequently with sulphate of strontian, as in Sicily.

¶ *Annales des Mines*, 4th series, vol. xviii, 1850.

** The tertiary beds of Teruel, in which the lymnea are filled with sulphur, without destroying the shell, and where this same substance has replaced the fibre in the stem of the *chara*, are well known from the descriptions given by Esquerra del Bayo, Max Braun, De Verneuil, and Collomb.

†† Pallas, vol. i, p. 197 and 202; *Russia*, by Murchison.

‡‡ It is doubless owing to a phenomenon of this kind that the sheathing of ships in some of the African seas is attacked, as also the fact observed by Captain Wilmot on this coast that there is deposited from the sea a mixture containing nearly an equal weight of organic matter and sulphur.—(*Institut.*, March 13, 1844.)

epigeny between the gypsum and the sulphur. We may remark, however, that the first phenomenon appears to be almost always accompanied by a high temperature, while the reduction of sulphates, even in a state of solution, appears paralyzed by every elevation of temperature capable of stopping the putrid fermentation or the decomposition which organic matter spontaneously undergoes.*

Bitumens and other carburets of hydrogen, according as they are in a solid, liquid, or gaseous state, sometimes impregnate beds, sometimes flow from them, (petroleum,) sometimes escape from the soil, as in the salses, mud volcanoes, and inflammable springs, which are in general only the vents of bituminous deposits.† The different formations of bitumen present as general, or at least, remarkably frequent characteristics:

1. Of being associated with salt bearing formations, (Soultz-sous-Forets in the Bas-Rhin, Landes; salt mines of Teklenbourg, in the north of Germany; decrepitating salts of Wieliczka and other parts of the Carpathian mountains, Brassa, near Spalatro; in Dalmatia, Albania, Persia, China, United States, &c.)

2. Of being situated in the neighborhood of combustible deposits or formations containing beds of vegetable remains, (Lobsann, Basses-Alps; Seefeld and Hering, in Tyrol; Bovey, in Devonshire; Derbyshire, environs of New Castle and of Glasgow, &c.)

3. Of being connected with accidents of igneous origin, both ancient and modern; that is to say, volcanoes or eruptive rocks, (Val de Noto, near Etna; Auvergne; Gaujac, in the Landes, where bitumen flows, at the foot of a peak of ophite, from a saliferous formation containing lignite; Java, Cape Verd,) or of being associated with dislocated formations, (Hering, in the Tyrol, salses of the Crimea, and of the promontory of Taman‡ and of the Caspian sea, which are in the prolongation of Caucasus.)

4. Of being often accompanied by sulphurous hot springs and deposits of sulphur, (permian formation of the Volga, promontory of Kertch, and various localities near the Caucasus, environs of Mosul, in Persia.) These two last circumstances seem to result from the associations of which we have spoken above.

Several of my experiments account for these relations. By submitting pieces of wood to the action of superheated water I have transformed them, in the midst of the water itself, into lignite, coal, or anthracite according to the temperature, and have moreover obtained liquid and volatile products resembling natural bitumens, and

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*The reduction of a sulphate to a sulphuret, according to the experiments of De Senarmont, does not take place at high temperatures. Thus the conditions that are favorable to putrid fermentation are also suitable for the reduction of sulphates to sulphurets.

I will add besides that the sulphuret of copper is formed and crystallizes in the hot springs of Plombieres, at a temperature of about 70° centigrade, as I have elsewhere announced.—(*Annales des Mines*, 5th series, vol. xii., p. 294.) This phenomenon of reduction explains, perhaps, the origin of some beds of metallic sulphurets, such as the copper bearing schists of Mansfield.

†This last relation is apparent in the Appenines, in Albania, in the promontory of Taman, and in the environs of Tiflis, &c.

‡ *Mémoires de la Société Géologique de France*, vol. iii, 1838.

even possessing the characteristic odor of the petroleum of Bechelbronn. In this way we can understand the presence of bitumen in some concretionary metalliferous veins, (Derbyshire, Camsdorf, Raibl in Carinthia.)

In short, the bitumens are probably derived from vegetable substances;* they appear not to be the products of a simple dry distillation, but to have been formed with the co-operation of water, and perhaps under pressure; graphite would be but the most exhausted product of these substances.† These different combinations of carbon are connected with the transformations which are going on in the interior of rocks, probably under the influence of a high temperature. The activity, and even the violence, sometimes capable of producing a slight earthquake, with which the disengagement of carburetted hydrogen takes place in Tauris, on the borders of the Caspian sea, and in the environs of Carthagena, in South America, prove that the causes which have formerly isolated bitumen are still in activity.

CHAPTER V.

METALLIFEROUS DEPOSITS IN THEIR RELATION TO METAMORPHISM.

Metallic combinations, derived from the interior of the earth, are very frequently accumulated in the clefts which exist in the strata, and have formed metallic veins. Sometimes also these and the various other combinations which accompany them are diffused through the rocks, and in penetrating them have caused them to undergo very decided transformations. It is thus that the masses of specular iron of Framont, the deposits of the Banat, of the environs of Christiania, and of Turjinsk, have been introduced in the neighborhood of eruptive rocks. In these localities the metallic minerals have been intermingled with silicates, produced at the same time with them in the sedimentary rock itself. In this way tin has been introduced in many of the formations where it is now found, reacting profoundly on the surrounding rocks, as I long ago pointed out, and forming in those rocks characteristic minerals.

When entire masses of rock have undergone transformations, it sometimes happens that, over vast extents, metallic substances have been lodged between their lamellæ, under such circumstances that it is impossible to resist the idea that their presence has been intimately connected with the very cause which produced the metamorphism. As an example, I mention gold associated with iron pyrites or with mispickel at Zillerthal in the Tyrol, at Galicia in Spain, where it is also accompanied with tin; but it is especially in the Oural,

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* Although Berthelot and other chemists have been able by ingenious methods to obtain by synthesis the compounds which are called organic, nothing authorizes us for the present to believe that this can be done for the bitumens.

† Graphite and bitumen are associated in Java in the neighborhood of volcanic formations, and with lignite in a tertiary formation, from which jets of carburetted hydrogen escape.

in Brazil, and in the Alleghanies,* that these formations, at the same time gold-bearing and metamorphic, attain great dimensions. In short, the metalliferous deposits, as well as the silicious discharges which furrow many countries, are but peculiarities of metamorphic phenomena.

CHAPTER VI.

DECOMPOSITION OF SILICIOUS ROCKS, AND MINERAL SPRINGS.

Causes, which appear to have some analogy with those which have changed the sedimentary deposits into crystalline rocks, have often produced an inverse effect, and have transformed silicious crystalline rocks into hydrated silicates; sometimes earthy and amorphous, such as clays, steatite, seladonite; sometimes crystalline, as the zeolites. We know, especially since the researches of Ebelmen, how atmospheric agents gradually decompose the silicious rocks.† The carbonic acid of the atmosphere, the nitric acid which is there daily developed, as the very general phenomenon of nitrification proves—in fine, the organic acids resulting from the decomposition of vegetable matter, gradually dissolve out the alkalies and the alkaline earths, and the residues, in which alumina is more and more concentrated, finally become hydrosilicates of alumina of the family of clays. But it is not alone in the neighborhood of the atmosphere that clays may have been derived from the transformation of crystalline silicious rocks. Volcanic fumaroles often reduce the masses through which they pass into real clays, ordinarily variegated, (Lipari islands, Solfatares of Pouzzoli, Iceland, Azores, Kamtschatka.)‡ This is, without doubt, the origin of the mud sometimes thrown out by the great volcanoes of the Andes. Carbonic acid, as Fournet long ago discovered in Auverne, itself suffices to produce analogous decomposition. The alkaline solutions which many hot springs contain, those of Plombieres, for instance, appear to decompose the silicious rocks as effectually as the acids of the fumaroles.

Like effects are often found in the neighborhood of metalliferous deposits. Thus the beds of kaolin, in Saxony, certainly result from a decomposition of granite near veins of iron, which traverse it; this example may be considered as the type of many facts of the same kind.§ The various masses of kaolin which are worked in Cornwall

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* A recent memoir of Leiber on this country gives interesting and detailed accounts.

† I can only mention here the important labors of Fuchs, Berthier, Forchhammer, Turner, Fournet, Al. Brongniart, Malaguti, and others on this subject.

‡ According to the observations of Breislack, Hoffman, Bunsen, Darwin, and others. Charles Deville has explained by an experiment this reaction of sulphuretted hydrogen on rocks.

§ Sosa, in Saxnoy, near a vein of quartz containing iron ore; environs of Alençon, near a vein of quartz; deposits of the Loire, according to Gruner and Rozet; decomposed feldspar of the arkose of central France,&c.; halloysite of Louhassoa, near Bayonne; kaolin of Eschassieres, (Allier,) in feldspathic porphyry, according to Boulanger.

It was facts of this kind that induced Brongniart and Malaguti to attribute the decomposition of feldspar to voltaic action.

are also associated with deposits of tin; they bear, as long ago remarked, the date and trace of their origin, in the substitution of oxide of tin and of tourmalin for the crystals of feldspar which have been dissolved. The kaolin of Middletown, in Connecticut, situated near silicates containing fluor and columbite, probably result from a like action.

These last facts authorize us to think that analogous phenomena must have produced the decomposition of crystalline rocks into kaolin, even where we do not now find any traces of metalliferous deposits; for, in this case, it is possible that the waters which have acted did not contain any metallic solutions. Thus the granite of the Vosges is often altered to a very great depth, especially at Plombieres. Sometimes even, as I have elsewhere shown, the decomposition and regeneration of feldspar have often taken place at neighboring points, thus constituting, as it were, two complementary phenomena.*

It is, perhaps, to agencies of the same character that we must attribute the transformation of entire masses of feldspathic porphyry to clay, which has caused this variety to be called in Germany *thonporphyr;* the crystals of feldspar, although perfectly formed, are in general nothing but kaolin.

The springs of Plombieres, which have afforded us examples of the production of minerals, also show that some hydrosilicates of alumina of the group of clays do not originate from a decomposition in position. Halloysite, (or savon de Plombieres,) of which these springs bring the elements in solution from the interior of the earth, is deposited in the channels of the springs like a true chemical precipitate.† A similar origin may be attributed to the halloysites, lithomarges, and other hydrosilicates of alumina, which in central France, in the Hartz, in Saxony, and elsewhere, often accompany the metalliferous deposits bordering upon granite.‡ We shall show further on that the zeolites also are often the result of a real epigeney.

With regard to the frequent substitution of the silicates of magnesia, steatite, serpentine, and talc, or chlorite, for different minerals, it appears to result from processes of tranformation, not without analogy with those which we have just been considering.§

If we take metamorphism in the most extended sense of the word, some phenomena of a superficial origin would perhaps be found indi-

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* *Annales des Mines*, 5th series, vol. xii, p. 315; 1857.

† *Bulletin de la Société Geologique de France*, 2d series, vol. xvi, p. 567.

‡ *Annales des Mines*, 2d series, vol. iii, p. 255; 3d series. vol. iii, p. 393.

Halloysites with manganese, near Nontron and Thiviers; with galena and calamine, at Villefranche, Angleur near Liege, Vieille-Montagne, Tarnowitz; with oxide of iron, at la Voulte; with oxide of tin, at Ehrenfriendersdorf, Zinnwald, &c.

§ Attention was long ago directed to the epigenies, of which we know remarkable examples at Gopfersgrun and Thiersheim near Wunsiedel in Franconia; at Snarum in Norway; at Predazzo in Tyrol; in Canada, and in the crystalline rocks of the Alps, including protogene. Blum, Bischof, Volger, and others have made numerous remarks on the probable origin of these interesting substitutions.

The hypothesis of an epigeny is confirmed by an observation made by de Senarmont, that crystals of serpentine, cut in thin plates, allow the light to pass without giving it any of those properties which characterize a true crystal, and which, consequently, do not belong to crystals *sui generis*.—(*Annales des Mines*, 5th series, vol. viii, p. 495.)

rectly connected with the subject which occupies us; as the precipitation of iron ores in bogs, the production of nitrates, the formation of carbonate of soda at the bottom of lakes and that of clay stones, the decomposition of pebbles into kaolin, &c. But it would be difficult here to embrace in their whole extent these incipient transformations which are, as it were, the life of the inorganic world. I shall confine myself to activities of a *deeper origin.*

THIRD PART.

THEORETICAL CONSIDERATIONS ON THE CAUSE OF METAMORPHIC PHENOMENA: SYNTHETICAL EXPERIMENTS IN SUPPORT OF THEM.

In the theoretical considerations which I am about to present, I shall first treat of those rocks whose metamorphic origin is demonstrated by the circumstances in which they are found. The oldest crystalline rocks, which have also been sometimes considered as metamorphic, but without the same corroborative proofs, will be the subject of an appendix which terminates this essay. With regard to dolomites, and the rocks which are connected with them, I shall add nothing to the facts and explanations which I have noticed in the second part.

CHAPTER I.

INTERNAL HEAT; ITS EFFECT ON METAMORPHISM; IT IS NOT SUFFICIENT TO EXPLAIN ALL THE PHENOMENA.

The modifications undergone by the formations comprised under the name of metamorphic have incontestably taken place at a higher temperature than that which we now have on the surface of the globe. We can infer it, in the first place, from the single fact of the mineralogical analogies which these formations have with the eruptive rocks, and especially the presence of numerous anhydrous silicates, which forms one of their most remarkable features; in the second place, from their evident relation to the dislocations, whose starting point is always in the interior regions of the earth, and which incontestably are referred to the internal heat of the globe as a first cause.

The heat of the globe necessarily decreases from the centre towards the surface, and consequently when the sediments deposited in the ocean at the relatively low temperature which exists in its deeper parts were afterwards covered by other beds, they must have acquired a greater degree of heat by reason of their greater

remoteness from the surface of radiation.* The superposition of heavy detritus, as in some stratified formations, was often sufficient to cause a notable increase of the heat of the masses beneath, after their deposit, especially at epochs when the increase of heat, in a vertical line, was subject to a much more rapid law than now.

This observation may be added: that the bottom of the greater part of the ocean does not now appear to exceed the temperature of from three to four degrees centigrade, owing to the single fact that a sedimentary deposit would be dried up in the temperate regions, and that its surface would consequently gain several degrees of mean temperature, all the points situated on the same vertical should increase in temperature equally.† Thus the regular propagation of the heat of the globe might have acted upon entire formations, and produced upon them a gradual transformation which Elie de Beaumont characterized under the name of *normal metamorphism.*

Setting aside the effects of this general, and, as it were, latent cause, there are circumscribed places where the heat has come very near the surface, especially in the suite of eruptive rocks. Hence there are special centres around which internal heat has produced *accidental metamorphism* or *metamorphism of juxtaposition.* Nevertheless there are very strong reasons for thinking that in both one and the other case it is not heat alone that has acted. Even when the temperature was sufficiently high to produce a softening of the transformed rocks, which is most frequently altogether improbable,‡ it would be insufficient to explain the diversity of effects which have been ascertained. The following observations prove it: If heat alone is the cause of the modifications observed in formations, the thickness of which is often more than a thousand yards, how did its action penetrate through such an extent? Why, at least, in accordance with the known laws of the propagation of heat and the feeble conductability of rocks, is it not of incomparably less energy in the remote parts than in those near the surface by which it arrived? This, however, is not the case, and the grandeur, as well as the uniformity of effects produced in entire mountainous masses is a phenomenon of the most striking significance.§ Moreover, if, setting aside the relations of the general whole, we pass to facts of detail, we still find in the manner of grouping of the minerals of the metamorphic rocks a multitude of circumstances of association or of formation which forbid our admitting for those minerals an origin due to heat alone. To cite an example, I will mention the very frequent occurrence of

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* This remark is due to Mr. Babbage, (*London and Edinburgh Philosophical Magazine*, V, 213.) Sir John Herschel has made some experiments on the chemical reactions which the strata have undergone owing to this ulterior elevation of temperature.—(*Leonhard's Jarbuch*, 1838, p. 98; 1839, p. 347.)

The bottom of the sea being at a low temperature, Hutton's idea of the heating of the sedimentary deposits cannot be admitted in the terms in which he described it.

† According to an observation of Sir John Herschel, noticed above.

‡ Bischof and Durocher have insisted upon arguments of this kind.

§ Often, also, in metamorphism of juxtaposition, it is not always in the parts the nearest to the contact of the eruptive rocks that the effects have been most energetic. Durocher has given several examples of this kind.

crystallized silicates of alumina, as chiastolite and staurotide, in the midst of phyllades containing fossils, as well as that of garnet, pyroxene, or feldspar in limestone, also of sedimentary origin, which very often are not sensibly modified. Heat, and the crystallization which is a consequence of cooling, might, it is true, cause a separation or liquation between substances which were primitively dissolved, the one in the other. It is thus that carbon is separated in crystals from cast iron in the state of graphite. But direct experiment shows us nothing analogous to the development of isolated crystals of garnet, pyroxene, feldspar, and disthene, by the agencies of heat, in a calcareous gangue, which has not even been softened, and which, according to all appearances, has been very feebly heated.* We can conceive that the slow agencies which nature often employs to form mineral products are perfectly capable of producing results which man is entirely unable to imitate; but have we the right to seek for explanations which there is nothing else to justify, exclusively, in the duration of time and in vague causes which are, so to speak, occult?

The same mineral is often found entirely isolated and crystallized in very different matrices; tourmaline, mica, feldspar, garnet, and epidote, for instance, are often found with the same characters in the midst of quartz, or imbedded in limestone or dolomite. This independence of the silicates in relation to their gangue appears to show that minerals are not the simple products of liquation, since media so different would not have secreted identical combinations. Besides, we meet everywhere in metamorphic rocks with minerals very unequally fusible, which have crystallized in a succession entirely opposed to the order of their fusibility.

Arguments of various natures, therefore, oppose themselves to the admission that a metamorphism having no other cause than heat could have given rise to the minerals that we find in the rocks which have undergone its action, even when they do not appear to contain simple bodies foreign to their primitive normal condition. But how much more is this conclusion to be relied upon when we see, as in Brazil, the altered condition of the rocks visibly coincide with the introduction of peculiar bodies, which, according to all probability, could not have come there until after their formation.

CHAPTER II.

OF CERTAIN VAPORS CONSIDERED AS AUXILIARIES TO HEAT; THEIR ACTION COMBINED WITH HEAT IS STILL INSUFFICIENT.

If heat alone could not produce the effects of which we have just spoken, will its action, aided by certain bodies, either gaseous or

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* The association of graphite, with the silicates having protoxide of iron for a base, as mica and amphibole, could not have taken place at a high temperature, (*Bischof's Geologie*, vol. ii, p. 60,) for at the least a partial reduction of iron to a metallic state would have resulted. The frequent presence of graphite in limestone led Bischof to the same conclusion, for the two bodies at a high temperature would react the one on the other.

easily reducible to vapor, become sufficient for their explanation? This is the first idea which naturally presents itself to our minds; for nature shows us an abundance of vapors of energetic affinities in the exhalations from the craters of volcanoes or their still incandescent lavas. These vapors and gases are combinations in which electro-negative bodies predominate, which the former mineralogists called, as if by instinct, the *mineralisers*, as chlorine, sulphur, carbon, more rarely fluorine and boron. The recent observations of Boussingault, Bunsen, and Charles Deville, have contributed to make known the nature of these gaseous or volatile ejections.

Carbonic, sulphydric, and even sulphuric acid might formerly have acted on some rocks in a manner similar to what we now see in some formations of gypsum and of alunite, or in the rocks near the volcanoes of the Andes and of Java, which are reduced under their action to mere mud. The decomposition of vapors containing chlorine forms under our eyes specular iron, and might have heretofore given rise in many formations to oxide of tin and of titanium, as both observation and synthetical experiment have taught us. It is in a similar manner that crystallized magnesia or periclase contained in the limestones thrown out of Mount Somma, might have been produced from the decomposition of chloride of magnesium by carbonate of lime. This supposition, which the abundance of chloruretted vapors of the active volcano rendered probable, has been corroborated by an experiment in which I artificially imitated that mineral.* It is remarkable to see the same substances which have produced periclase at the expense of the limestone form, when in solution and at a lower temperature, dolomite. The part which these chlorures at high temperatures have borne in producing the crystallization of minerals is clearly shown from the very recent experiments of Manross, Forchhammer, and Henry Deville.

Other experiments have shown that the chlorides of silicium and of aluminum by reacting, in a state of vapor, on the bases which enter into the composition of rocks, form simple or multiple silicates which are identical with natural products.† But if mica subjected to heat still gives off the fluorides of silicium, boron, and lithium, shall we venture to affirm that granitic pastes did not also originally contain the chlorides of silicium, boron, and lithium, although we do not now find them in the neighborhood of volcanic orifices? for they could not be otherwise than decomposed and precipitated by the vapor of water before arriving in the atmosphere. Do we not still see chlorine fixed in considerable quantities in crystalline masses, as in the syenite containing zircon, of Norway, and in the rock of Ilmen, (miascite,) where it is principally combined with eleolite, and where it appears in the train of zirconium, tantalium, and other rare elements, which are almost exclusively peculiar to those rocks? With regard to fluo-

* Researches on the artificial production of minerals belonging to the families of the silicates and the aluminates by the action of vapors on rocks.—(*Comptes Rendus de l'Académie*, vol. xxxix, p. 135.)

† *Comptes Rendus de l'Académie*, vol. xxxix, p. 135.

rine and boron,* I long ago showed that they appear to have been instrumental in the formation of masses of tin.† In effect they enter into the composition of characteristic silicates, as topaz and tourmaline, which were certainly formed at the same time as the oxide of tin.‡

These conclusions are equally applicable to the rocks whose origin is due, according to all probability, to analogous phenomena. Such is the well known rock found at Schneckenstein, in Saxony, where topaz and tourmaline appear to have glided between the divisions of the schists, at the same time cementing, in conjunction with quartz, the numerous fragments into which this schist had been broken. The same is true of entire formations in Brazil, such as those that contain topaz in the county of Villarica—schists in which gold and the diamond with the same characteristic minerals have been found over vast extents of country. These formations are, as it were, but an accumulation over a great space of the habitual gangues of oxide of tin.§ There still remains in granite a sufficiently sensible quantity of fluorine and of boron to allow us to admit that it is possible that this rock, before solidifying, gave off large quantities of vapors in which those two bodies were in combination. These ideas on the intervention of fluorine and boron, which date twenty years back, have acquired still greater value since Henry Deville has crystallized a series of minerals by the aid of the fluorides, and since the presence of fluorine and boron has been discovered in many mineral waters, and fluorine even in sea-water.

We can explain by heat, accompanied by the auxiliaries which have just been mentioned, a greater number of transformations than by heat alone; but with those agents only we cannot explain some very important circumstances, except by attributing to the vapors a part evidently much exaggerated. Bischof, and other savans have clearly substantiated this fact by numerous considerations.||

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* The presence of fluor, already discovered in different modern volcanic rocks, has been verified by M. Scacchi in a recent deposit of the fumaroles of Vesuvius. With regard to boron, the enormous quantities which come from the *saffioni* of Tuscany and the extensive deposits of the craters of volcanoes hardly permit us to doubt that it exists in many other localities which have been passed unnoticed up to the present time.

† On the origin and artificial production of oxide of tin.—(*Annales des Mines*, 3d series, vol xx, p. 65, 1841; 4th series, vol. xvii, p. 129, 1849)

‡ This first comparison between boron and tin, established on purely geological grounds, has been followed by the discovery of an unexpected analogy between two bodies whose chemical properties are so different. I speak of their isomorphism, which has been demonstrated by the labors of M. Sella.

§ I am very far from thinking that these different quartzose rocks have been formed without the presence of water. I shall presently revert to this subject.

|| How, for instance, can we admit of such an origin for the formation of crystals of feldspar or garnet in regular strata, which are often hardly modified at all?

CHAPTER III.

WATER CONSIDERED AS AN AGENT OF METAMORPHISM.

But in volcanic exhalations there is a body which did not at first attract attention, because under the dominion of former ideas it seemed altogether inert, especially in the presence of minerals whose formation was to be explained. It does not exist in minute quantities like the vapors of which we have just spoken; it is, on the contrary, at the same time, the most abundant and the most constant product in all the eruptions of the globe. This body is water, and we shall see that the most important part was assigned to it in metamorphic phenomena, as well as in the eruptions of volcanoes. The singular property which the incandescent silicates of lavas possess of retaining for a very long period, even up to the time of their solidification, considerable quantities of water, clearly proves that the action of heat does not exclude that of water, and appears also to show that water has even at high temperatures a certain affinity for these silicates.

Of the masses situated at a certain depth in our globe, we only know what is brought up by volcanoes. Now, these ejections all, without exception, contain water, either combined or mixed; we are, therefore, justified in thinking that water plays a very important part in the principal phenomona which have their origin in the depths of the earth. We have seen, in the historical part of this work, that conclusive arguments have caused a most powerful action to be attributed to water, such as the formation of many metalliferous veins, and an incontestable influence in the crystallization of the eruptive rocks themselves, comprising granite. In truth, the hottest lavas, and those which are most charged with water, as basalts and trachytes, do not modify rocks to any considerable depth; but this is, without doubt, owing to the fact that as soon as they are exposed to simple atmospheric pressure, the water escapes by being reduced to the state of vapor. The numerous blocks of limestone in the tufas of Mount Somma, which have come from the seat of volcanic action, show, in their numerous geodes, adorned with such a variety of, and such well crystallized minerals, what rocks may undergo, when, under pressure, they are subjected to the permanent action of certain agents, without which some of these agents would not have acquired their power, and others not even have existed.

Something altogether like this is seen in the little basaltic mass of Kaiserstuhl in the Grand Duchy of Baden.* A strip of limestone, torn off by the action of basalt from the formations which it has traversed, has been modified by it most completely. This limestone has become entirely lamellar, and contains crystals of titaniferous magnetic iron, iron pyrites, magnesian mica, perowskite, pyrochlore, crystallized quartz, and innumerable needles of apatite. The very

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* *Annales des Mines*, 5th series, vol. xii, p. 322; Naumann, *Geognosie*, vol. i, p. 791.

exceptional peculiarity among rocks in contact with basalt, which characterizes the limestone of Kaiserstuhl, appears to me to result from the conditions of its formation. This limestone was situated at the bottom of a crater of elevation. Before the last dislocation, undergone by the formation, brought the limestone to the surface, it had been subjected, at a certain depth, and consequently under pressure, to the action of the hot water with which the basalt itself was saturated, and which also deposited minerals in its numberless cavities. The limestones of Mount Somma, so rich in various minerals, and those of Latium, have been produced, like the limestones of Kaiserstuhl, at points where craters of elevation have been formed. When the beds which hermetically sealed the spot where these chemical reactions took place gave vent, in breaking, to the agents which produced them, these reactions ceased to take place. But what difference of action can there be, in the case of which we are now speaking, between what passed on the surface and what took place in the depths of the earth? No other, according to all appearance, than that which is owing to difference of pressure. Let us add, that if the vapor of water which, at a very high temperature, no less than liquid water up to its point of ebullition, fail to produce, in the ordinary experiments on the silicates, results like those which the metamorphic formations present, it is because something essential is wanting, and everything shows that what is wanting is pressure.

In fine, we have just seen on what grounds we may rightfully suspect the concurrence of heat, water, and pressure, as capable of producing the principal phenomena of metamorphism. What is wanting is to place ourselves in conditions resembling, as much as possible, those under which nature appears to have acted, and to see whether the reproduction of characteristic minerals would be obtained. Such is the object of a series of experiments which I have undertaken, and of which I am about to give an account.

CHAPTER IV.

EXPERIMENTS ON THE ACTION OF SUPERHEATED WATER IN THE FORMATION OF SILICATES.

Several of my experiments have been already described in a former memoir.* I have thought proper, however, to reproduce here the principal results which were recorded in my first publication, and to add to them those which I have more lately obtained. Even counting for nothing the dangers of explosion, which are often of a violence altogether surprising,† the difficulties of experimenting have

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* *Annales des Mines*, 5th series, vol. xii, p. 289, 1857; *Bulletin de la Société Géologique de France*, 2d series, vol. xv, p. 97, 1858.

† Tubes made of iron of the best quality, having an interior diameter of 0.8 inch and 0.4 inch in thickness, sometimes burst. They break in the direction of one of their generatrices, and are thrown into the air with a noise like the report of a cannon. If the iron

prevented me from multiplying results as it would have been desirable to do. The facts, however, already discovered are conclusive, and show the fecundity of this method of experimenting.

The principal difficulty consists in finding walls and fastenings that will resist for a sufficient length of time the enormous tension which steam acquires when the temperature is raised towards a dull red heat. Water and the matters that are to react are placed in a glass tube, which is then sealed. This glass tube is next introduced into a very thick tube of iron, which is closed in a forge at one of its ends. The other end is often closed by means of a screw, having a square head, which can be turned with a wrench. Between the head of the screw, which should be made with great precision, and the end of the tube a washer of very pure copper is placed; it should be thin enough to be crushed by the pressure when the tube is closed, and penetrate into the grooves made for that purpose. For closing the second extremity, however, I have now adopted another plan in preference; I introduce hot a very strong bolt, which, if the welding is skilfully done, becomes part of the tube. A workman must be very skilful to succeed in this operation; for it is essential that the greater part of the tube remain cold, in order that the water in the interior may not, by evaporating, hinder the operation. To counterbalance in the interior of the glass tube the tension of the steam, which might burst it, water is poured around it, between its sides and those of the iron tube which surrounds it. In this way the principal strain is put upon the latter tube, which offers the most resistance. This apparatus, like those which de Senamont used, is laid on the dome, or in the conduits of the retort-furnace of a gas-works in contact with the masonry, which is at a dull red heat, and is buried beneath a thick bed of sand. At a temperature which is a little below nascent red heat water reacts very energetically on certain silicates.

In this manner ordinary glass, at the expiration of a few days, gives two, and often three, distinct products: 1. A white and altogether opaque mass, which results from the complete transformation of the glass; it is porous, sticks to the tongue, and would look like kaolin if it were not for its very decidedly fibrous structure. The substance has lost a large part of its weight, nearly half its silica, and a third of its alkali; a new silicate has been formed which has fixed the water, and belongs, by its composition, to the family of the zeolites.* 2. An alkaline silicate which has been dissolved, carrying with it the alumina. 3. Often there are developed, in addition, numerous perfectly limpid and colorless crystals, which have the ordinary

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had no fault, and we suppose that it preserves at 300° centigrade the same tenacity as when cold, such an explosion would indicate an interior pressure of more than 1,000 atmospheres.

It is to be noticed that, before bursting, the tube swells out into the form of an ampulla of one and a half to two inches in length, and opens in its middle so as strikingly to call to mind the gibbosity of the profile of Etna, with the central notch of the Val de Bove, the origin of which was long since, by de Buch and Elie de Beaumont, attributed to an expansive force of the same kind.

* *Bulletin de la Société Géologique de France*, 2d series, vol. xvi, p. 588. At a higher temperature an anhydrous silicate, which appears to resemble wollastonite, is obtained.

pyramidal form of quartz, and which, in reality, is nothing more than crystallized quartz. Some crystals, thus formed, have attained at the end of a month .07 of an inch in length. Sometimes they are isolated in the opaque paste, sometimes lodged on the sides of the glass tube, where they form veritable geodes, which, with the exception of their size, it would be impossible to distinguish from those so frequently found in crystalline rocks. What renders this transformation of glass still more remarkable in a geological as well as a chemical point of view is, that it is obtained with a very small quantity of water, which in weight is not equal to a third of that of the transformed glass.

Volcanic glass, known under the name of obsidian, acts in a manner similar to the artificial. Pieces of obsidian, heated under the same conditions, are changed into a gray product of a crystalline nature, having the aspect of a fine-grained trachyte. Its powder, examined under the microscope, presents exactly the characters of crystalline feldspar, and especially resembles rhyacolite or vitreous feldspar. In fact, we know that obsidian greatly resembles feldspar in its chemical composition; favorable circumstances would, without doubt. have determined the reunion of its elements in definite proportions. The tendency of forming in the wet way that feldspar thus manifests is to be taken into account in divers geological circumstances.

With the fragments of obsidian on which I operated there were pieces of vitreous feldspar detached from a trachyte of Drachenfels, and, also, a piece of oligloclase from Sweden. These two last minerals underwent no appreciable change.* We cannot, however, affirm that if the water had not immediately found an alkali to remove from the vitreous envelope it would not have acted upon the feldspar. We here see a kind of a confirmation of the preceding experiment on the stability of the silicates, which have, perhaps, originally crystallized in conditions very similar to those in which they were again placed. The same is very nearly true of thin laminæ of the potash mica of Siberia; they hardly lost their transparency. Crystals of pyroxene also do not change their aspect, except that, like the pieces of feldspar and obsidian, they are so completely enveloped with crystals of quartz that it is necessary to break in order to recognize them.

To examine, as far at least as the presence of glass will permit, how the solutions of natural silicates which we usually find in water act when superheated, I used water from the hot springs of Plombieres, which is comparatively rich in silicates of potash and soda.

Not being able, however, to operate on more than from twenty to thirty cubic centimetres, I concentrated it beforehand by an evaporation so rapid that the carbonic acid of the air did not sensibly decompose the silicates, and in such a way as to reduce it to one-twentieth of its former volume. After an experiment that was stopped at the end of only two days the sides of the tube were already covered with a silicious coating in the form of crystallized quartz, and also of chalce-

*Feldspar, however, can be decomposed cold by trituration.—(*Annales des Mines*, 5th series, vol. xii, p. 547.)

dony. As the glass was as yet only altered on its surface, this deposit must have come, almost all of it at least, from the decomposition of the alkaline silicate contained in the water of Plombieres. Thus, without the use of a single chemical reagent, under the single influence of heat, water holding alkaline silicates, such as those of the springs of Plombieres in solution, deposits crystallized or crystalline quarts.

A new proof of the facility with which minerals of the feldspar group can be produced in the presence of water is furnished by the following experiment, which I made with a view of explaining the feldspathization of many rocks, even those containing fossils. Kaolin, perfectly purified from all feldspathic debris, by washing, having been treated in a tube with water from Plombieres, this earthy mass was transformed into a solid substance, confusedly crystallized in little prisms which scratched glass. After having purified this substance by washing it with hot water, we find that it has become fusible into a white enamel; chlorhydric acid no longer attacks it. It is a double silicate of alumina and an alkali, having all the characters of a feldspar; it is mixed with a little crystallized quartz. The reaction which we have just explained may be compared to the ease with which a cold silicate of alumina absorbs lime in hydraulic mortar. On the surface and in the interior of the whitish mass resulting from the transformation of the tube I found a great quantity of very small crystals, but of a perfectly distinct form, having great brilliancy and perfectly transparent; they had different tints of green, and many of them that olive-green tint which is peculiar to peridot. Their form is that of an oblique symmetric prism, the bases of which are replaced by two bevels; the two opposite edges are ordinarily truncated, as in the pyroxene which Haüy called homonome. These crystals scratch glass very perceptibly; they remain unaltered in the presence of concentrated and boiling chlorhydric acid. They melt before the blow pipe into a black enamel. In fine, they have the composition of a *pyroxene*, having a base of lime and iron; and from their transparency, they belong to the variety *diopside*. Some of these crystals are isolated, some grouped together in such a way as to form little globules bristling with points, and more rarely they are under the form of thin incrustations. All of them, by their aspect, immediately recall the best known crystals of diopside.

The clay of Klingenberg, near Cologne, which is used to make glass-house pots, when heated in glass tubes, is covered with a multitude of white, pearly pellicles, possessing the lustre of mica. They are hexagonal, and have an optical axis of double refraction.* They are fusible, and indicate before the blow-pipe the presence of silica. They are attacked by chlorhydric acid, which manifests the reactions of alumina. The quantity of these pellicules that I have obtained has been as yet too small to permit of my making a quantitative analysis. It appears, however, very probable that the substance is a mica of one axis or a chlorite.

* According to an examination which M. de Sénarmont was kind enough to make.

The fossil vegetables having undergone modifications under the influence of the same agents as stony matters, it is proper to see what becomes of wood in superheated water. Fragments of spruce were transformed into a black mass, having a bright lustre, perfectly compact—in a word, presenting the aspect of a pure anthracite; it was so hard that a steel point could with difficulty scratch it. This kind of anthracite, although infusible, is entirely granulated under the form of regular globules of different dimensions, from which it clearly results that the substance has been melted in the process of transformation; by calcination it yields only traces of volatile matter; the ligneous matter has therefore arrived at its last stage of decomposition. This kind of compact carbon burns very slowly, even under the oxidizing flame of the blow-pipe. It differs from the carbons formed at high temperatures in the fact that, like the diamond, it does not conduct electricity. The veins of silver at Kongsberg, in Norway, which are encased in gneiss, contain anthracite which very much resembles the artificial anthracite we have just mentioned. It has moulded itself in the midst of carbonate of lime and native silver, under a form that shows that it has passed through a softened state. At lower temperatures, but in conditions otherwise analogous, wood is transformed into a kind of lignite or coal. In these experiments I obtained, as I have before said, liquid and volatile products resembling natural bitumens, and possessing even their characteristic odor.

To recapitulate: superheated water has a very energetic influence on the silicates; it dissolves a great many of them, destroys some combinations of multiple bases, and forms new ones, either hydrated or anhydrous; in fine, it causes those new silicates to crystallize far below their point of fusion. In these changes the silicic acid, set at liberty, isolates itself under the form of crystallized quartz. Transformations so complete are, moreover, obtained with a very small quantity of water. In general we can distinguish this law, that near the point of nascent red heat the affinities of the wet way acquire, so far as concerns the production of silicates, the same character with those of the dry way.

CHAPTER V.

DEDUCTIONS DRAWN FROM THE PRECEDING EXPERIMENTS, FOR THE EXPLANATION OF THE CRYSTALLIZATION OF SILICIOUS, ERUPTIVE, AND METAMORPHIC ROCKS.

The results which we have just given enable us to account for what takes place in the crystallization of silicious rocks in general, as well the eruptive as the metamorphic. Let us first examine the former of these, commencing with the lavas.

Whatever may be the molecular state of the water in lavas, it intervenes to cause them to crystallize much in the same way as in the experiments of the laboratory for transforming obsidian into crystallized feldspar, and for producing pyroxene in perfect crystals. Thus, in

one as in the other case, the water appears to favor the *elimination* of substances which would remain mixed, and to permit the crystallization of silicates at a temperature very much lower than their point of fusion.* It is again through the influence of this kind of mother water that the same silicates crystallize in a succession which is often opposed to their relative order of fusibility. We know, for instance, that amphigene, a silicate of alumina and potash, which is infusible, has been developed in the lavas of Italy in crystals which are often very large, and in which are imbedded numerous crystals of pyroxene, a substance of known fusibility. These apparent anomalies are shown in a still more striking manner in granite, which differs from all the products of dry fusion with which we are acquainted, and different conjectures have been offered to explain them. It can be explained nearly in the same manner; only in the formation of granite the action of water, according to the observations of Elie de Beaumont, appears to have been aided still more than in the lavas by some auxiliaries, such as the chlorides and the fluorides. In the feldspathic porphyries containing quartz, water alone would have sufficed to produce the bipyramidal crystals which characterize this rock. This is again another capital phenomenon which has nothing analogous in the products of the dry way.

The remarkable association of anhydrous and hydrous silicates which basalt, phonolite, and other rocks present, is not surprising after the experiments that I have just described. For during the same operation, and in the same tube, I have obtained crystals of pyroxene disseminated in the midst of a zeolite; that is to say, the two constitutive elements of basalt simultaneously. A still greater difficulty presented itself when, on the one hand, the soft state or even fluidity of some eruptive rocks was considered; and on the other, their low primitive heat, which is well established by different circumstances. This difficulty is also done away when we consider what has taken place in these same experiments. The glass tubes which were perfectly regular were found, after the operation, bent, deformed, and covered with ampullæ in such a manner as to prove that they had undergone an unmistakable softening. Furthermore, sometimes the tube had almost disappeared; it was transformed into a kind of mud, presenting probably great analogies, as well in consistence as in composition, with the original state of some eruptive rocks. A very remarkable phenomenon, to which I shall have occasion to revert, is here produced; although the glass in the transformation loses a part of its elements, it augments considerably in volume; this augmentation is more than a third of the primitive volume. When we see the important part which water plays in the phenomena just passed in review, should we not also be led, with still greater reason, to attribute to it the most important part in metamorphic action, especially

* I will here recall the opinion of Dolomieu on the crystallization of lavas: "I repeat, perhaps for the hundredth time, the compact lavas are not vitrifications, and their fluidity at their exit from volcanoes, which continues a much longer time than their cooling should permit, is the very singular effect of a cause which is not yet determined."—(*Journal des Mines*, No. 37, p. 402, 1797.)

if we consider the great extent and the remarkable uniformity of its action?

Before examining this latter agency of water, it seems natural to examine to what extent its presence is possible in rocks. Let us first say that it follows, from the experiments already cited, that a very small quantity of water only is necessary to produce, under favorable conditions of pressure and temperature, very marked changes. We cannot, in effect, see without astonishment that such a complete transformation in the chemical and physical state of glass can be obtained by a quantity of water equal to about a third of its weight. This shows us how the water of constitution of some rocks, as the clays for instance, was sufficient to produce metamorphism when heat gave it the power to react upon the elements with which it was associated.

With regard to those rocks which do not contain any water of constitution, let us first make the remark that many of them are destitute of the water called *quarry-water*. We cannot suppose that this water has been lodged otherwise than in the pores of the rock. All rocks are, therefore, porous; and what takes place in the artificial coloration of agates proves that stones which are in appearance perfectly compact are by virtue of the sole force of capillarity penetrated by a liquid.

We cannot deny that if water can insinuate itself, by crevasses, into the solid crust of the globe at a depth only equal to that of the sea, it acquires a pressure of several hundred atmospheres. by the aid of which it penetrates more easily, perhaps, into the most minute pores of the rocks, especially at the temperature which it possesses at such a depth. This action is, without doubt, aided by capillarity within limits of which we can form no idea. If, however, the rocks were altogether impermeable, provided the water be endowed with the power of attacking their surface, time only is necessary in order that its action should be gradually propagated to considerable distances. Indeed, in the tubes prematurely withdrawn I was able to see that the attack had taken place by successive layers, in such a way that there yet existed between the two surfaces of the glass a portion that was transparent and altogether unaltered. Thus, whether the water of rocks is that of constitution or penetration, we are justified in expecting, as soon as the temperature is sufficiently raised, reactions comparable to those produced in our experiments, as well as in eruptive rocks. This, however, will be verified by an example as conclusive as surprising, which abounds in new facts, and has the double merit of being contemporaneous, and of having been performed under conditions which are now perfectly well known.

CHAPTER VI.

CONTEMPORANEOUS METAMORPHISM OF PLOMBIÈRES.

The concrete which the Romans put down nearly to the points of emergence of the thermal springs is composed of fragments of brick

and of party-colored grit, without admixture of sand, and cemented by lime. It rests sometimes on the granite itself, sometimes on alluvial gravel. Under the prolonged action of the mineral water, which continually penetrates this mass of concrete, I have found that the calcareous cement and the bricks have been partially transformed.* The new combinations appear chiefly in the cavities of the mass, where they form mamliated and sometimes crystallized coatings. The products, the most remarkable on account of their abundance, are the silicates of the family of the zeolites, and especially apophyllite, chabasite, and harmotome. Besides the presence of the zeolites, which have crystallized in the cavities, the pieces of brick which form a part of the Roman concrete have often acquired a very peculiar aspect; they have been thoroughly impregnated with silicates, resembling those which have crystallized in geodes; they have undergone a genuine metamorphism. I have been able to determine accurately all the conditions under which this metamorphism has taken place.

Notwithstanding its extreme hardness, the Roman masonry gives access to the thermal water as well by its pores as by the fissures and cavities that exist in it. The pressure from the springs, moreover, forces the water to circulate slowly through the mass, which is thus not only bathed but *traversed* by the mineral water. The water, therefore, is not stagnant; there is a *current*, very slow it is true, but this current is continuous. On the other hand, the mineral water of Plombieres contains only a very small quantity of saline matter, (4.6 grains to 60 cubic inches of water,) which is composed in part of silica, potash, soda, lime, and alumina; but continual renewing and indefinitely prolonged action permit deposits of these substances to accumulate in notable quantities. It is in this way that very feeble agencies are multiplied by the aid of time. Up to the present moment this condition of time is wanting in the greater part of the experiments attempted for the purpose of imitating nature; but its capital influence over certain geological phenomena will be easily appreciated.

By means of the alkali which this water contains it gradually acts upon some of the substances which it traverses, and perhaps even without there having been a real solution, but only a kind of cementation. It then causes the formation of double hydrous silicates, which belong to the group of the zeolites. It is to the union of these two circumstances, circulation of the water and its chemical agency, that these modern formations are due. In order that the silicates which are formed should crystallize perfectly, there is really no necessity for so high a degree of heat as has been supposed; a temperature of from 60° to 70° centigrade, which is that of the mineral springs of Plombieres, is sufficient for the production of at least some of them. Zeolites have consequently often been formed in this rock under simple atmospheric pressure, and even on the surface of the soil. It is remarkable to see these silicates crystallizing perfectly, in water, at a

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* *Annales des Mines*, 5th series, vol. xiii, p. 227, 1858; *Bulletin de la Société Géologique de France*, 2d series, vol. xvi, p. 562.

temperature at which they are reputed to be insoluble in it. At points as near each other as a few sixteenths of an inch we see different products forming, according to the nature of the substance on which the water acts. Thus it is that apophyllite, a silicate containing lime as well as potash, crystallizes in the cavities of the lime. I have never met with it in the brick. It is, on the contrary, almost exclusively in the cavities of this last that we find chabasite, a double silicate of alumina and potash. The same solution, therefore, attacking rocks of different natures, develops combinations special to each of them. Such a marked localization of certain zeolites appears to show that their elements were not entirely contained in the water imbibed by the masonry; it only contributed a part. The complementary elements necessary to the composition of the new minerals, lime, alumina, and others, were contained either in the mortar or in the bricks which gave them up to the water.

While the bed of concrete abounds in zeolites, the alluvial sand over which the masonry was built presents no indication of the formation of these silicates, although the thermal water traverses it before reaching the concrete. It confines itself to depositing between the interstices of the pebbles a yellowish argillacious mass, which is one of those imperfectly defined substances known under the name of chemical clays or halloysites. This contrast shows further that the zeolites are not the first deposit of the thermal water, but that it is produced only by the reaction of this mineralized water on other silicates.

What is going on at Plombieres has been evidently accomplished on a wide scale in certain geological formations. The collection of minerals disseminated in the innumerable cellules of the masonry, the zeolites, opal, and arragonite, constitutes an association which is frequently the appendage of certain eruptive rocks. Furthermore, the whole of the conditions under which these contemporaneous minerals exist recall, in the most minute particulars, their disposition in the layers of basalt and trap, which have an amygdaloidal structure. If it were not for the difference of color it would be quite possible to mistake the parts of this concrete which contain the zeolites for the basaltic traps in which the same minerals have been formed. The bricks, with their cavities and druses, surprisingly imitate amygdaloidal rocks. Such an identity of results incontestibly indicates striking analogies of origin. Near the volcanic rocks of Ætna, of Iceland, and other countries, we find a rock to which the name *palagonite** has been given. This hydrous silicate is easily fusible, gives a jelly with acids, has often a resinous aspect, presents the strongest analogy with the silicates of Plombieres, and, according to all probability, results from a transformation similar to that which gave rise to these last. But it is especially with regard to metamorphism that we should here state the results of the action of the springs at Plombieres.

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* Rammelsberg, *Chemische Mineralogie*, 3d and 5th supplement, pp. 93 and 185; *Annales des Mines*, 5th series, vol. xii, p. 474.

CHAPTER VII.

CONCLUSIONS TO BE DRAWN FROM THE FACTS OBSERVED AT PLOMBIERES.

It has been justly remarked that there are but few insoluble substances when the solvents circulate by millions of gallons. Yet we must not conclude from this that the insoluble minerals formed by water in the interior of rocks have been purely and simply deposited by it after the action of centuries. One of the newest and most important facts which reveals what is going on at Plombieres is, that in general only a small part of the elements constituting these minerals is furnished by water. The other elements pre-existed in the rocks, and appearing to obey an energetic tendency to crystallization they seize, as it were, upon what first passes, according to their affinities, and the mineral is, so to speak, formed in situ.

In metalliferous veins, on the contrary, almost everything that is deposited in the channel of circulation of the spring appears to be foreign to the rock forming its sides. These are the very different effects of the same cause, and their union in the same place, at Plombieres, leaves no doubt of their common origin.

There is a striking analogy between the formation of the crystallized silicates of the concrete of Plombieres and the formation of the silicates which are found in a great many metamorphic rocks; such are wernerite, garnet, feldspar, and pyroxene in limestones, often hardly modified at all; and macle or staurotide in argillaceous schists. The production of mica in rocks is not more difficult to understand than that of apophyllite at Plombieres, which is also a silicate containing fluor.

When a dislocation produces a group of hot springs is it not probable that the greater part of the formations traversed by these springs will undergo an action of which an idea is given by what has happened at Plombieres? This action, gradually extending with the aid of time, would occasion metamorphism over zones of very great extent. At Plombieres, before the hollowing out of the valley gave issue to the springs, the thermal water already arrived from the interior of the earth,* and if it appeared on the surface it was, without doubt, only by a scarcely apparent transudation. In diffusing itself through the beds of the lower triassic formation, which are in contact with the granite, it deposited there jasper, crystallized quartz, and several other products. Thus water circulating in the interior may cause a very energetic metamorphic action without evidence of its existence being shown on the surface by thermal springs. It is probable that in many cases the silicification of polyps and wood in certain beds, the precipitation of crystallized quartz in others, such as those that are found in the tertiary basin of Paris, the complete silicification of some beds that were formerly limestone† have no

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* See the memoir on Plombières, referred to above.—(*Annales des Mines*, 5th series, vol. xiii, p. 232; *Bulletin de la Société Géologique de France*, 2d series, vol xvi, p. 562.)

† *Description Geologique du Bas Rhin*, pp. 325 and 326.

other origin. A tepid and scarcely mineralized water has been sufficient to transform this masonry and produce in it hydrated and crystallized silicates. Would not the effect have been much more considerable if water greatly superheated, and yet retained by the pressure of the masses above, had slowly circulated across certain rocks, as it has done in the concrete of Plombières, and had acted on them at the high temperatures which are necessary to the formation of anhydrous silicates?

CHAPTER VIII.

OTHER PECULIARITIES OF METAMORPHISM EXPLAINED BY THE AID OF THE FACTS MENTIONED IN CHAPTERS IV AND VI.

In comparing the results obtained by the experiments on superheated water, with the facts gleaned from the contemporaneous phenomena of Plombieres, we can explain the greater part of the phenomena of metamorphism. I shall add only a few examples to those of which I have spoken above. One is the well-known development of pyroxene and amphibole in the secondary limestones of the Hebrides and the Pyrenees. I will mention also the production of such various minerals in the blocks of limestone of Mount Somma, the geodes of which are incrusted with diopside, mica, and other substances. A frequent phenomenon of metamorphic rocks is the development of feldspar in their mass. Among the numerous facts of this kind, I will recall the schistose formations which border upon granite, (Britanny, Saxony, &c.,) and even the schistose masses near which we do not see any eruptive rock, (Taunus, Ardennes, &c.) In the carboniferous formations of the Vosges, at Thann, for instance, the perfectly regular beds of greywacke are studded with crystals of feldspar, which have isolated themselves from a petrosilicious base; the numerous vegetable fossils which the rocks contain will not allow of its being considered as a porphyry. The limestone of Mont Blanc, formerly noticed by Brochant, and which Brongniart named *calciphyre feldspathique*, has peculiar analogies. We should not, however, lose sight of the fact that here, as in other cases of the same kind, the limestone which has thus been modified has not always changed its primitively compact for a crystalline state.

Among the frequent associations of anhydrous and hydrous silicates, I shall restrain myself to mentioning the chloritic rocks which form the gangue of tourmaline, amphibole, pyroxene, &c. The crystals of the feldspar called adularia, which are penetrated with chlorite, (Pfitschen, in Tyrol,) sometimes even with stilbite, (Sella, or St. Gothard,) show us that the anhydrous were even sometimes crystallized after the hydrous silicates.*

* Although chlorite has not yet been imitated, we may believe, from its chemical analogies to the zeolites, as well as from the preference it shows for those formations which have undergone a commencement of modification, as the schistose formations of the Ardennes, that it has been formed at a high temperature.

In the silicious rocks quartz has been isolated in a great variety of forms. The granitic rocks and some porphyries contain it in grains or in isolated crystals. In the schistose rocks it is sometimes under the form of veins or thin flakes, lodged between the lamillæ, with an uniformity of thickness and parallelism that is surprising, as in mica, chlorite, and talcose schist, leptinites, phyllades, &c., sometimes under the form of veins which distinctly cut the lamellæ at the same time that it attaches itself to them. Sometimes, even, quartz in a granular state constitutes considerable masses, as in the rocks (itacolumites) of Brazil, which are associated with gold and diamonds. In the greater number of cases, however, quartz appears to be the product of a decomposition of silicates, just as in my own experiments, where it was produced in different ways. Thus quartz, which under so many forms constitutes a part of eruptive and metamorphic rocks, should be considered equally with that of veins as a witness for the wet way.*

We may conclude from what happens in the experiments on superheated water, as from the example of limestones so charged with minerals, which are thrown out from the interior of Mount Somma, that heat and pressure appear to be indispensable to the production of an energetic metamorphism. On the other hand, an intense metamorphism has been sometimes developed near the surface, as in Brazil, where the crystalline schists containing gems extend more than 200 miles in length. There seems to be a contradiction between these two facts, and yet, when the superheated water is impelled from great depths toward the surface through the substance or the scarcely opened fissures of a rock, it must be remarked that the laws of hydrostatic pressure are not applicable to it, as it would be to water ascending freely in a crevasse. We can easily understand that in the first case its pressure, and consequently its temperature, might be preserved, as it were, in a close vessel, up to only a few feet from the surface. It is therefore possible that many phenomena, such as the crystallization of granite and of certain masses of tin, which contain the same minerals as the rocks of Brazil, may have taken place under pressure, although at no great depth.

It is possible that some minerals, the anhydrous silicates, for instance, are not easily produced in water except at determinate temperatures. Too much heat, as well as a want of heat, is prejudicial to their formation. Moreover, experiment seems to show that the feldspars are sometimes produced and sometimes destroyed in water, according to the temperature. It is probable, that because in some parts of the Alps, such as the Grisons, the higher portions alone furnished a proper temperature, that metamorphism and the various minerals which are, as it were, witnesses, have been produced there rather than in the beds situated lower down, whose section we can follow in the

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* My experiments thus fully confirm the views which Schafhaüt and Bischof have published on this subject.

immense chasms.* This fact would be analogous to the condensation, in the superficial beds of volcanic mountains and of lavas, of sal ammoniac, the different chlorides, sulphur and specular iron, or to the well-known enrichment of numerous metallic veins in their upper part.

To sum up, when we are to explain the origin and the formation of silicates in most of the rocks, it is not to the dry but really to the hydrothermal way that we must oftenest have recourse. This assertion is founded on the following considerations:

1. Formation by the wet way takes place at temperatures incomparably lower than the point of fusion; this is a condition of which we have previously recognized the necessity.

2. The hydrated silicates which we find in nature often associated with anhydrous silicates are easily formed in the wet way, as we have seen, at the same time as these last (zeolites with pyroxene, chloritic schist with tourmaline and feldspar, &c.); their formation is with difficulty explained in the dry way.

3. Quartz is extremely abundant in nature. Now, as soon as superheated water is in contact with a great number of silicates, soluble or insoluble, we see that a part of the silica isolates itself and becomes a genuine crystalline quartz, which does not at all resemble the glass produced by the fusion of quartz.

It will be remembered in effect that silica, whether melted or obtained by the decomposition of the silicates, has none of the properties of quartz; that it is not as dense, nor as refractive, nor as hard, nor as refractory with alcaline agents.† It is possible that this difference of properties is the cause of the easy decomposition of the vitreous silicates: the menstruum attacking the silica under its soluble modification, then, perhaps, without there being any necessity for a change of circumstances, they precipitate it under the modification corresponding to insoluble quartz, only serving then, so to speak, to cause the silica to pass by a kind of continuous evolution from one molecular state to the opposite‡.

4. In fine, instead of uniform masses, such as fusion generally produces, we see in the products of the wet way mixtures of different crystallized substances, whose mode of association is entirely independent, as is the case with the greater part of rocks of their relative degrees of fusibility.

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* This fact, which results from former and unedited observations of Elie de Beaumont, has been recently pointed out also by Sir Roderick Murchison.

† Pogg. Annalen, 1859.

‡ Stannic acid presents something similar, when we see one of its modifications, (stannic acid, properly so called) passing by the simple action of heat to the other state of modification, (metastanic acid,) and thus separating itself from certain solvents.

CHAPTER IX.

APPLICATION OF THE SAME FACTS TO ERUPTIVE ROCKS.

Eruptive rocks present a great analogy of composition with metamorphic rocks; many minerals are, in fact, common to the one and the other. It is thus that the elements of granite (feldspar, mica, and quartz) are often found in the beds that it has traversed, and where they are, as it were, extravasated.* When granite or syenite have enclosed fragments of pre-existing rocks, they have even been in some sort assimilated, as I have elsewhere shown.† We find a very remarkable example of this in the masses of compact limestone of Mount Somma, in the interior of which, amphigene, sodalite, and anorthite, have crystallized, as well as in the lavas which are adjacent to them. The limestone of Kaiserstuhl, with its titaniferous oxydulated iron, its pyrochlore, its perowskite, its apatite, manifests also its relation with the doleritic rock, which has furnished the principal elements of these minerals. It is on this resemblance of composition, sometimes striking, that the conclusion that the minerals of metamorphic rocks have been produced in the dry way has often been based.

I will reverse the argument by saying that if components, such as feldspar, mica, quartz, amphigene, pyroxene, &c., are found in stratified rocks, under conditions where they could not have been formed but by the intervention of water, we ought to regard it as very probable that water has acted in the same way in the crystallization of the eruptive rocks themselves, a conclusion to which we have before been drawn by other considerations. If it were necessary to propose an hypothesis on this singular association of water with eruptive rocks endued with a high temperature, we should be apt to consider these hydrated masses as a very concentrated solution of the silicates, a kind of watery fusion rendered persistent by pressure.

When these silicates have crystallized, their mother-water, accompanied by various substances,‡ has disengaged itself from them, preserving, however, a temperature and a pressure sufficiently great to penetrate into the surrounding rocks and modify them extensively. From this fact result, perhaps, the analogies which have been mentioned above between the eruptive rock and the rock which has been traversed. Thus to recapitulate and follow out the part that we are led to assign to water in eruptive rocks, I will say that we can distinguish three principal agencies, which it exercises under three conditions: 1. Arriving in a state of combination with these rocks, of which, with the concurrence of heat, it causes the softening; 2. Disengaging itself from the rocks as they consolidate, traversing and metamorphosing the neighboring rocks; 3. Escaping sometimes to

* According to the numerous observations of Elie de Beaumont, de la Bèche, Gruner, Naumann, and many others.

† *Annales des Mines*, 5th series, vol. xii, p. 319.

‡ Like the chlorides of the lavas.

the surface, either in a state of vapor or as hot springs.* Let us remark, however, that this *extravasement* of minerals ready formed, of which I spoke above, is, without doubt, only an appearance, and that the feldspar or the mica which is in the neighborhood of granite was probably formed in situ by borrowing, as at Plombieres, a part of its elements from the medium in which it was developed.

It is here that we may advert, in a few words, to the singular destiny of pyroxene. The crystals of pyroxene, so frequently disseminated in lavas, were formerly considered as having been detached from a pre-existing rock, and, to better express the idea already put forth by Dolomieu, that they were not formed in the volcanic rocks which contain them, but that they had been simply imbedded in them. Haüy gave its name to pyroxene, in the sense which its derivation indicates—*stranger to fire*.† Afterwards it was ascertained that, on the contrary, it had crystallized in the lavas, especially since the experiments of Berthier and Mitscheralich, and it has been considered as the type and exclusive product of the dry way. Is it not strange to see that, by its great tendency to form in superheated water, it is this mineral which appears at the present time the most important among the best characterized products of this new method? Let us add, further, that water might have had its influence even in the mechanical action of the eruptive rocks. Indeed, in the recital of my experiments I have designedly dwelt on the augmentation of volume which glass transformed into a zeolite by the agency of water has undergone, in order to draw from it the conclusion that, in all probability, at the moment of their hydration certain rocks have undergone a phenomenon of increase analogous to that of which we have numerous natural examples when anhydrite changes into gypsum. This increase was probably sufficient in many cases to bring about the extrusion and the eruption of rocks; this would be particularly the case with phonolites and basalts.

CHAPTER XI.

METAMORPHISM OF STRUCTURE; ITS RELATIONS TO ORDINARY METAMORPHISM.

We have seen, in the first and second part of this memoir, that the schistose structure appears to be the result of pressure and of slips undergone by the strata under the action of energetic forces. The experiments on this subject, which I undertook before knowing of those of Mr. Tyndall, but which I made by other processes and on a larger scale, confirm this theory. I used for the purpose powerful

* To this are to be referred the springs of which metalliferous veins and other deposits neighboring on eruptive rocks attest the existence. They have probably, with time, diminished in temperature and volume, and have at last dried up, when the masses from which they came arrived at their last stage of consolidation and refrigeration.

† "The name pyroxene apprises us that the crystals of lavas are not in their native place."—(*Mineralogie de Haüy*, 1st edition, vol. iii, p. 90.)

means of compression, not only rolling-mills, but also the lever presses moved by steam, which are used to stamp sheet iron into various utensils. All these methods of compression, whether gradual or by shocks, were successively employed. The matter upon which I principally operated was clay brought to a peculiar state of desiccation.* The clay submitted to these different processes of compression acquires a very marked schistose structure;† but for that, besides pressure, two other conditions are indispensable.

1st. It is necessary that the substance be capable of sliding and extending itself by an inchoate lamination; then the lamellæ develop themselves parallel to the sides—that is to say, normally as regards the pressure. No result is obtained if the body cannot yield and change its form in the direction perpendicular to the pressure. A piece of clay, cylindrical in form, placed in a cylinder of cast iron of the same form and dimension, was powerfully compressed by a piston of the same calibre. The substance acquired very great consistency, but showed no indication of lamellæ, not even of cleavage. This, I repeat, takes place only when the mass of earth fits exactly in its rigid envelope; otherwise deformation takes place, and consequently the formation of lamellæ.

2d. The substance to be compressed ought to possess a high degree of plasticity. Too dry, it breaks; too soft, it becomes laminated without any lamellar structure being perfected. Specimens of the same clay in different states of dryness, submitted simultaneously to compression, furnish superposed layers, some of a schistose structure, others of an irregular fracture, whose contrast is very significative. I have tried also to produce by the same process the schistose structure of the silicates at the moment when they pass from a state of fusion to a solid state. The slags of iron blast furnaces which I submitted to pressure while they were still in a state of paste did not become schistose. The fracture of the cooled mass only showed different colored veins in lines normal to the pressure. What I have said above, concerning the influence of plasticity in the formation of the lamellæ, explains the frequent transitions which we see in the same mass of partially schistose rocks. It is thus that, to cite an example, the porphyry of Mairus in the Ardennes, becomes gradually schistose.

It is proper here to call to mind that glass acquires a very remarkable schistose structure from causes entirely different from those which we have just mentioned. At the same time that the glass tube transformed by superheated water swells considerably it takes this schistose structure in a very marked manner. The lamellæ into which it easily cleaves, are so thin that sometimes more than ten can be distinguished in a thickness of the sixteenth of an inch.‡ When

* These experiments took place at the factory of Karcher and Westermann, at Ars-sur-Moselle. I used especially the refractory clay of Villy-en-Trode, (Aube,) which comes from the neocomian formation and from the grey supraliasic marls.

† Certain tiles obtained by a peculiar process of moulding which is employed at Epinal, also often present a commencement of the foliated structure.

‡ Sometimes they can be as neatly detached the one from the other as the leaves of a quire of paper.

the glass is incompletely acted upon, the centre, although still vitreous, also shows very fine zones, like onyx, the whole reminding us of the characteristics of certain schistose and crystalline rocks. The schistose structure which the glass tubes acquire is evidently the effect of their mode of fabrication, which has given to the mass a structure by superposed layers. It is a species of heterogeneity which can be made evident by the subtle action of polarized light, but which, to the naked eye, is at first concealed by an apparent homogeneity. It appears when water, by an unequal action, has marked out the zones of different natures, and still better when the substance already modified in part has undergone contraction. These lamellæ are, in effect, more apparent in some tubes than in others. A manifest proof of a fact of which we find different examples in manufacturing,* and which shows how the primitive disposition of the constituent materials of a rock, although they may have disappeared by ulterior action, may still be present in a latent state, and reveal themselves when new influences bring them to light.†

A phenomenon which almost always accompanies a schistose structure in crystalline rocks, is the remarkable parallelism which a part of these crystalline elements presents.‡ Those which have the form of spangles, whatever may be their nature—mica, chlorite, talc, graphite, or specular iron—are arranged flatwise, according to the planes of their lamellæ; sometimes they even present a sort of alignment, which has been called *linear parallelism*, as if there had been a drawing out. The chlorite, micaceous, and talcose schists offer the best characterized examples of this phenomenon.

It is even to these spangles, which were supposed to assume an arrangement in parallel planes under the influence of calorific or magnetic action, that, in accordance with the views of Sir John Herschel,§ the cause of the lamellar structure has often been attributed. Sorby has sought to confirm this influence of spangles by an experiment which consists in laminating a mass of paste containing them. I cannot accede to this view, and I think that the alignment of the spangles, instead of being the cause, is, on the contrary, only the consequence of the pre-existence of these lamellæ. I found my opinion on four principal reasons : 1st. A lamellar structure is sometimes developed in nature, and I have seen it perfectly produced, in the experiment previously cited, in the absence of all kinds of spangles. 2d. Crystals which are far from having the lamellar form, as

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* We know, for instance, that in shaping pieces of porcelain clay, the person who does the rough work at the lathe and the moulder must take great care to produce an *equal* pressure on all the parts of the piece which they are executing. Very small inequalities of pressure, at first completely imperceptible, become evident after baking by numbers of irregularities, some of which are known under the name of *screwing*, (vissage.)—(Brongniart, *Arts céramiques*, vol. i, p. 123.)

The fabrication of Chinese image mirrors appears to be founded on a principle of the same kind.

† The experiments which I have recently made bring out the schistose structure in a metal which would seem as little disposed to acquire it as brass.

‡ All the schistose minerals and rocks do not show this alignment; thus the macles are not in general disposed parallel to the layers of the phyllades, of which they form a part.

§ *Manual of Geology*, Lyell, 1857, vol. ii, p. 447.

garnet and magnetic iron, present, notwithstanding, a very regular alignment. 3d. I have observed, in experiments similar to those of Sorby, that the spangles really have a tendency to arrange themselves gradually in the direction of the movement determined by the pressure, in such a way that the friction resulting from the sliding will be the least possible. Nevertheless, their alignment is very imperfect in comparison with that of nature, often so remarkable in its regularity, and that of these spangles, those which are not able to arrange themselves in the general plane, appear to disturb the formation of the lamellæ. 4th. A process has given me results which are almost identical with those of nature; it consists in impregnating clay, before submitting it to lamination, with water heated to 100° centigrade, and saturated with boracic acid; then laminating it on a plate of cast iron heated by a furnace, so as to avoid the precipitation of the acid before the formation of lamellæ. But in this experiment the spangles of boracic acid, which are produced between the lamellæ by an ulterior cooling of the liquid, present an alignment infinitely more regular than in the experiment of Sorby, and altogether like that of certain micaceous schists.*

By comparing the facts which we have just cited with the data which the metamorphism at Plombières has furnished us, we arrive at a conclusion of the highest probability. If the materials, concrete or bricks, into which the water of Plombières penetrates had a lamellar structure, is it not evident that the mode of circulation of the water would have been influenced, and that the liquid veins insinuating themselves in preference between the layers would have given rise on their passage to crystals in lamellæ or otherwise sensibly aligned? In the case where the metamorphism would not have taken place but by a water of constitution, we yet comprehend that the crystals would be developed profiting by the planes of cleavage in the mass. The papyraceous arrangement, so remarkable in its regularity, which the quartz of some leptynites and porphyries presents, may have had an analogous origin, since, as we have seen, water intervenes also in the crystallization of eruptive rocks.

CHAPTER XII.

COMPARISON OF ALL THE PHENOMENA WHOSE SEAT IS IN THE INTERIOR OF THE EARTH.

If thermal springs are the agents of metamorphism, we need not be surprised that the same mode of metamorphism extends over extended regions, since we still see mineral waters grouped together in families of analogous composition in regions of great extent; thus they are generally carbonated in Auvergne and Eifel, sulphurous in

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* I do not, however, pretend to say that this lamination in some cases has not continued after the alignment of the spangles in the rocks; it is easy to be convinced of the contrary by examining the different schistose crystalline rocks.

the Pyrenees,* &c. We meet with these analogies still more strongly characterized in the metalliferous deposits, which appear to be also a product of like origin, and although the greater part of them contain numerous mineral species often distributed in a very unequal manner in different parts of the same vein, the nature of the gangues, as well as that of the metals, which can be mined with profit, show they are generally grouped in systems. These systems sometimes embrace entire regions, especially on the continents whose geological structure is not parcelled out like that of Western Europe; as, for instance, the argentiferous groups of Mexico, the great auriferous bands of the Alleghanies and Brazil, the stanniferous zone of Malaya.

The same fact is well known of volcanoes. If there are any that are isolated, the greater part constitute a *series*, as de Buch long ago demonstrated, when he compared them to vents which had been formed on a line of the same great fault. As to earthquakes, we shall only mention them to associate them with volcanoes, to which they seem so intimately related.

The families of thermal springs, of metalliferous veins, of volcanoes with their earthquakes, occupy extents quite comparable to those which we have established for regional metamorphism, the seat of which occupies entire countries. As with all these families, the metamorphic formations† are exclusively confined to regions where dislocations have taken place.

On the one hand, in effect, the oldest stratified formations of Russia and Southern Sweden, as well as those of North America, which have preserved their primitive horizontal position, are not sensibly transformed. On the other hand, the recent formations, but whose stratification is very much disturbed, such as the jurassic and cretaceous beds of the Alps, the Apennine mountains, and Tuscany, have, on the contrary, been entirely modified, even where there are only a few eruptive masses. The phyllades are but the first term of much deeper transformations; so they are never found outside of zones which have been more or less dislocated.

It is, then, difficult not to see, in these different kinds of phenomena of which I have just spoken, the manifestations of one and the same agent, whose seat extends beneath entire countries. This essential agent is water, aided by heat of different intensities, with which are joined, as secondary causes, the emanations which accompany it. For volcanoes the thing is evident; for metalliferous veins there can hardly be any doubt, especially after the labors of Elie de Beaumont and the experiments of de Senarmont; and with regard to metamorphism we think that our assertion has become extremely probable. Thus we think that water acts without cessation in the lower regions of the earth, after having there acquired a temperature

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* Longschamp remarked that in the entire length of this chain, which is more than sixty miles, there are more than one hundred and fifty springs, all of the same kind, and only differing within very narrow limits by the proportion of their elements.—(*Memoir read at the Academy of Sciences, August* 12, 1833.)

† At the least, those that are posterior to the silurian formation.

more or less elevated by means of the heat of the globe. Its action is at some points *patent*, demonstrated as it is by volcanoes, earthquakes, solfionis, and hot springs which issue on the surface; at other points it is *latent*, where the thermal springs, possessed of an ascensional motion, are lost by reason of the thickness of the beds, or when the water of constitution only of the rocks reacts upon them and produces metamorphism. Such is the idea which has dictated the title inscribed at the head of this memoir.

APPENDIX.

CONSIDERATIONS ON THE FORMATION OF THE SCHISTOSE ROCKS WHICH PRECEDED THE SILURIAN PERIOD.

Below the silurian formation we only know at present of rocks which are eminently crystalline. In general the passage from the one to the other is gradual, but sometimes the line of demarcation is quite evident, as in Sweden, Finland, and the United States. Thus the oldest beds (Potsdam sandstone) which this last region of the globe presents have undergone no modification, and rest horizontally upon the azoic formations with vertical lamellæ.*

The effects of metamorphic action show themselves, as we have seen, in the formations of different ages. It is the oldest beds, however, which have the most completely undergone this action. The cause which produced it appears, therefore, to have been enfeebled by time, and to have probably possessed, before the silurian formation, a considerable energy, that is to say, that it evinced itself nearer the surface. Thus we comprehend why very many geologists thought that they saw in these antesilurian deposits the first sedimentary beds, but that they had undergone a metamorphism. This supposition is supported by the great resemblance between the primitive and stratified rocks, whose metamorphic origin is not doubted. As in these last, so in the midst of gneiss, which constitutes the greater part of the formations of which we are speaking, we find limestones, dolomites, amphibolic schists, quartzites, petrosilicious rocks, (halleflinta of the Swedes,) and masses of metallic ores, which often cannot be distinguished from those found in the upper beds. This resemblance is so striking in the limestones, on account of the minerals which they contain, and their mode of association, that we might, for instance, easily confound the crystalline limestones containing spinel and chondrodite, which are subordinated to the gneiss of Pargas, in Finland, or Canada, with those of Monzoni, in Tyrol, and of Mount Somma, which belong to formations comparatively recent.

As still another analogous fact, we should mention graphite, or the

* Foster & Whitney's sketch of the silurian formation of Lake Superior.—(*Bulletin de la Société Géologique de France*, 2d series, vol. viii, p. 89.)

carbonaceous combinations which we meet with in the more ancient formations,* (graphite of St. Marie-aux-Mines, anthracite of Konigsberg, in Norway, or of Dannemora, where it is in a gray limestone hardly crystalline, bitumen of the veins of granite of Finbo, near Fahlun, and the numerous iron formations of Sweden.)

Other geologists, on the contrary, struck with the intimate connexion which exists between the granite and this gneiss, have considered the latter as a granite which has become schistose by having been flattened out. If this was so, it would be necessary to conclude that certain masses of limestone, quartzite, magnetic iron, and other metallic ores, pre-existed in the granite, and that they have been softened at the same time with it, so as to be susceptible of being extended simultaneously, and thus take the form of plates parallel to the foliations of gneiss, imitating stratification in a very striking manner. This is a supposition that can hardly be admitted.

There are still two important remarks to be made on this subject: 1st. The absence of transition in the azoic schistose rocks of the silurian formation shows that the first rocks had already acquired their crystalline state, before the deposit of the oldest known fossiliferous rocks. This fact is confirmed by the pebbles of well characterized gneiss, which the formations of transition sometimes contain. 2d. There is no indication that these same ancient rocks have in certain countries ever been covered by any considerable thickness of other rocks, otherwise we should have to admit, and we have no ground for doing so, that extended and scarcely undulated countries like Scandinavia or Canada, have undergone enormous denudations. Besides, formations like those of Scandinavia and North America, which we have just cited as examples, are found in all parts of the globe with analogous characters; they form almost universally a kind of covering for granite.

Supposing that the mass of all our seas were diffused as vapor in the atmosphere, the pressure on the surface of the globe would amount to at least two hundred and fifty times what it now is;† it would even be greater by reason of the intervention of gases and of other vapors. There could, then, not have existed liquid waters on the earth, until the temperature of its surface was reduced below that degree of heat which can give to the vapor of water a tension of two hundred and fifty atmospheres. The surface of the globe, then, was at that epoch at a very high temperature, and if there existed any silicates on the surface of the earth they must have been formed in the dry way. Afterwards, when water had commenced forming in the liquid state, it would have reacted on these previously existing silicates, and would have given rise to an entire series of new pro-

* So long as synthesis, which in the hands of Berthelot had led to much remarkable results, has not imitated the anthracites of Sweden without the aid of plants, we must believe that these combustibles are of vegetable origin, and consequently that the plants existed when the gneiss which these deposits contain was formed.

† Admitting, with Baron Humboldt, a mean depth of 1,900 fathoms for the ocean, we should have 1,400 fathoms as the depth of a bed of water uniformly spread over the globe, which corresponds to a pressure of 248, or in round numbers 250 atmospheres.

ducts. By a true metamorphic action the water of this primitive ocean first caused the structure proper to these melted masses to disappear by penetrating them, and afterwards formed, as in our tubes, crystallized minerals by means of the very principles which had caused it to dissolve them. These matters formed or suspended in the midst of the liquid, would be precipitated to its bottom with variable characters in the deposit, in proportion as the heat of the liquid diminished. Are these different periods of chemical decomposition and recomposition, in which the wet way intervenes under those extreme conditions which touch so nearly on the dry way, the era of the formation of granite and of the schistose rocks which are altogether azoic and crystallized? We cannot affirm it absolutely, but we must presume so, especially if we consider that on this hypothesis there have been formed two series of products, the one entirely massive, the other presenting traces of sedimentary origin, and which connect themselves one with the other in an insensible manner. This, in effect, is what exists in nature with regard to granite and gneiss.

In concluding I will remark, that if there has ever been a time when rocks were exclusively under the dominion of the dry way, they have passed under the regime of the wet way at an epoch much more remote than has until lately been supposed. We can hardly find now on the globe rocks to which we can assign with entire certainty a formation exclusively due to the dry way, without any concurrence of water. There is, however, an example which shows us what rocks of such a kind might be, and it is furnished us by the aerolites. These bodies in effect do not offer in their essential constitution either water or hydrated combinations. Is it not singular that, formed of silicates of the same bases as those of our globe, they have never presented either quartz, mica, or granite, but bodies which we do not meet with on the crust of the earth, such as metallic iron and metallic phosphurets and carburets? The existence of these bodies appears wholly to protest against the presence of water. Is not this a new motive, although a little far-fetched it is true, for believing in the impotence of heat alone to produce granite?

According to the hypothesis which we have just mentioned, the first deposits of the sea would have remained a long time in a soft state eminently favorable to the production of the schistose structure. The lamellæ of these rocks, as well as of those of the more recent metamorphic formations, have in general a position near the vertical, even outside of mountain chains in countries like Sweden, the Limousin, and Moravia, the outlines of which present nothing peculiar. From what we have said above on the production of a lamellar structure, the lateral pressures to which it appears to owe its origin must have acted almost horizontally. They were probably of the same nature as the compression which afterwards gave rise, in more solid stratified formations, to those different foldings and convolutions which characterize mountain chains. Thus, as the fibrous structure of iron shows the mechanical action that it has undergone, so these more ancient formations appear even then to have testified to the force of

contraction which afterwards produced mountain chains. This force was perhaps limited in these first epochs to producing the schistose character of the rocks, at the same time that, by reason of their flexibility, it augmented their thickness by folding, while scarcely undulating them.

Whatever may be the fate of hypotheses by which we allow ourselves to be carried away, even while recognizing that they rest as yet on grounds not sufficiently solid, we have a right to believe that the older gneiss demonstrates the high temperature of the globe in very ancient times. The universal production of crystalline rocks in these fundamental formations concurs with the whole assemblage of metamorphic phenomena to compel the admission of a general cooling of the interior of the globe. It is an argument of the most positive nature to oppose to the indiscriminate partisans of existing causes, who, with Hutton, envelop the origin of our planet in a night of indefinite duration, during which geological phenomena never ceased to revolve in the same circle.

Although these questions are still very obscure, we discover a grand simplicity of agencies which have given rise to a great diversity of effects; and the immediate productions of a superheated sea, the crystallization of eruptive rocks, the metamorphism of stratified beds, appear to be only different modes of action of the same phenomenon in different ages. Conclusions less vague, however, should be adjourned to the time, perhaps not far distant, when we shall succeed in producing granite artificially. Synthetical experiment has already, since the time of Hall, been exceedingly useful, and it is to it that the office of throwing still more decisive light on a formation where direct observation has doubtless little more to learn, appears to belong. If experimentation, armed with its most ingenious processes, has been necessary for understanding the phenomena which belong to our own day, and of which we are witnesses at all times, such as the weight of air, lightning, &c., with how much greater reason ought we to have recourse to it when the question relates to geological facts, the most important of which are not now repeated at least under our observation, and have left as the only witness a final result, preserving no trace of the intermediate activities which have produced it?

Up to the end of the last century geology was altogether hypothetical; it then entered upon a positive career based upon the observation of facts and induction. It is not long since a new era seems to have opened in which it seeks light from phenomena of every order—chemical, physical, and mechanical—by synthetic experimentation, thus undergoing the phases which physics have passed through since the time of Galileo, to arrive at the point which it has now attained.

REPORT ON NITRIFICATION.

PRESENTED TO THE SMITHSONIAN INSTITUTION IN 1858.

BY DR. B. F. CRAIG.

I have the honor to acknowledge the receipt of a communication from the Smithsonian Institution, requesting me to furnish information and suggestions upon the subject of the formation of nitre, with especial reference to its production in this country, and in accordance with this request I respectfully submit the following.

An opinion upon any one branch of the subject of nitrification cannot be fairly based upon anything but a statement of our knowledge of the whole, nor can the practical value of any source of nitre be estimated without a comparison of it with other known or attainable means of supply. In order, then, to be enabled to give the required information, I have felt myself called upon to take up the whole subject of nitrification, a subject of much difficulty and intricacy, the obstacles to the study of which are increased by the circumstance that information on it is only to be found scattered here and there through the pages of scientific publications. The difficulties attending it, together with the pressure upon me of other occupations, I would offer as an apology for my delay in answering your communication. To obtain clear ideas on those points on which information is most to be desired, it will be necessary to consider the subject under the following heads:

1st. Our knowledge of the laws which govern the formation of nitre.

2d. The manner and extent of its production in nature.*

3d. The methods that have been practiced for its artificial formation.

4th. The methods of artificial formation that have been suggested, or those which the present state of our knowledge would suggest.

5th. The experimental investigations that it would be desirable to make, for the proper advancement of the theory and practice of the manufacture of nitre.

I. Since nitrates † are continually being produced under different cir-

* Nitre is not found accumulated in masses like most minerals, but forms continuously in various places, whence it is extracted from time to time.

† The nitrates that are to be met with where nitrification has taken place, and which, for the sake of convenience, may be spoken of as a class, include saltpetre or the nitrate of potash, the nitrate of soda, the nitrate of lime, and the nitrate of magnesia. Their chemical formulas are as follows:

Nitrate of potash,	NO_6 K.
Nitrate of soda,	NO_6 Na.
Nitrate of lime,	NO_6 Ca.
Nitrate of magnesia,	NO_6 Mg.

The three last are convertible by simple means into nitrate of potash, the conversion requiring, of course, a supply of potash, which is usually obtained in the form of a ley of wood ashes.

The nitrate of soda is met with in South America. Those occurring elsewhere are, mainly, the nitrate of lime and the nitrate of potash.

cumstances, it is natural that something should have been known about the manner of their formation from a very early period in the history of modern science. We find, accordingly, that as far back as the 17th century it was held that the origin of nitre was due to the decomposition of organic matters, both animal and vegetable. That nitrates have, in large part at least, such an origin has long been well established, and it has been the opinion of many that, whenever nitrates are formed, organic matters must be looked to as their source. The way in which such matters come to be the source of nitrates has been partially elucidated by modern investigations.

Organic bodies as they are found in nature contain nitrogen in greater or less quantity, and in decomposing they give it off in the form of ammonia,* which is known to be convertible by the joint action of oxidizing agents and of mineral bases, such as lime, potash, &c., into nitrates of those bases. It is shown by different examples, and by general chemical analogy, that this conversion is greatly facilitated by the presence of solid substances in a finely divided or porous condition, and we may assume that nitrates are formed from the ammonia given off from decomposing matters by the action on it of atmospheric oxygen, and of porous bodies containing lime, potash, and other mineral bases.† Experiments directly to this point are, those of the French Academy, by which it was found that chalk, hung up in a basket over decomposing blood, was partly converted into nitrate of lime;‡ and those of Dumas, who formed nitrates by passing ammonia, mixed with moist air at a temperature of 212° Fah., over pieces of chalk moistened with a solution of potash.§ Kuhlmann, who has made very important contributions to our knowledge of the subject, converted the compounds of ammonia into nitrates by means of various oxidizing agents.||

This last-named chemist also performed the converse experiment of producing ammonia from nitrates by the action on them of nascent hydrogen and of such reducing or deoxidizing agents as furnish hydrogen. Upon these experiments, and upon other facts, he based conclusions of considerable importance to agricultural chemistry. He sets forth that when nitrates are mixed with an ordinary soil at that depth below the surface at which they are out of contact of air, they are reduced to ammonia by the agency of the organic matter present; and that conversely, when the ammonia in the soil rising to the surface comes into contact with the air, it is converted into nitrates of lime, potash, and whatever other bases may be contained in that particular earth. The reduction of the nitrate to ammonia in the deeper

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* The chemical formula of ammonia is NH_3. It is evolved in the gaseous form, in combination with certain volatile acids, also the products of organic decomposition, chiefly with carbonic and hydrosulphuric acids.

† Good examples of such bodies are found in ordinary earth; and a mode of producing nitrates, long practiced and well known, consists in mixing earth with organic matters, and allowing decomposition to go on with exposure to the air.

‡ *Memoires des Savans Divers*, vol. xi.

§ *Comtes Rendus*, December, 1846.

|| *Comtes Rendus*, November, 1846.

soil prepares it for the food of the plant, and the ammonia that might have escaped from the surface of the ground by reason of its volatility is prevented from doing so by its conversion into non-volatile nitrate.*

Nitrification, being much influenced by the temperature, goes on with the most rapidity in tropical countries, and this Kuhlmann considers as one cause of their greater fertility, since but little ammonia can escape unaltered through the surface stratum of the soil in those regions. It is evident that during dry weather nitrates must accumulate at the surface of the ground, and that upon the occurrence of rain they must, being very soluble, be washed down into the soil, and be there reconverted into ammonia.

Another set of circumstances under which nitrates are generated from ammonia-yielding substances are those brought forward by Dr. R. A. Smith in his researches on the air and water of towns. He shows that the drainage from sinks, cesspools, and other depots of organic matter, undergoes oxidation in passing through water-bearing strata, the oxygen dissolved in the water co-operating with the porous soil to convert the nitrogen of the decomposing matter into nitrates, and the sulphur into sulphates.†

In this way water purifies itself from the contaminations that are so largely poured into it so effectually that a well separated from a sink by a few feet of porous soil will be kept free from offensive matter, the conditions required being that the medium through which the filtration takes place shall not be a surface soil which is too much loaded with organic matter for oxidation to go on in it; and that there shall be sufficient supply of water containing oxygen in solution, which, of course, must be the case wherever springs or wells occur. When well-water becomes charged with organic impurities, it is because the drainage through the surface soil enters the well without passing through the deeper or water-bearing strata. Thus the production of nitrates takes place both at the very surface and deep in the ground, while there is in fertile soils a middle zone charged with organic matter, where their conversion into ammonia goes on.

Until the present century it was universally believed that organic matters were necessary in every case of the formation of nitrates, and up to the present time the opinions of a number of scientific men seem to be inclined to the conclusion that wherever nitrates are produced in large quantity they originate from the decomposition of such substances. In 1823, however, Longchamp read a paper to the French Academy, in which he advanced the doctrine that nitrates are generated from the nitrogen of the air, and not from that of organic substances. Since the time of Cavendish it has been known that the nitrogen and oxygen of the air may be converted into nitric acid. If the electric spark be passed through air confined over a solution of potash, nitrate of potash is generated; if over simple water, we have nitrate of ammonia. Again: when a mixture of nitrogen and hydro-

* *Exps. sur la Theorie des Engrais, C. R.*, November, 1846.

† Proceedings of the British Association, p. 66, 1851.

gen is burnt in the air, or in oxygen, nitric acid is produced in small quantity.

The possibility of the formation of nitrates from the nitrogen of the air being established, Longchamp argued that in many cases of the occurrence of these bodies the supply of organic matters was too small to account for the whole quantity.

Facts* that were known then, and some that have since been observed, seem strongly to sustain Longchamp's position, and have inclined many chemists to look upon his views as in the highest degree probable, and as explaining a large part of the production of nitre; at the same time, however, not questioning the facts of the first-mentioned mode of nitrification.

There is great difficulty in demonstrating that in any given case of nitrification the nitrogen cannot all come from ammonia, since ammonia and ammonia-yielding substances reach the nitrifying soil, or rock, in so many ways and from so many sources. They exist everywhere—on the surface of the earth, in all soils, and in many rocks; they are diffused through the air and are washed down from it by rains, and the water which percolates through the earth often carries large quantities of them with it, so that, although it can be pointed out that in certain cases the supply of them seems too small to account for the whole production, yet it would be very hard to reduce this to positive demonstration.

While it has been long known that the nitrogen of the air will, under certain circumstances, enter into the composition of a nitrate, it has not until very recently been clearly shown by experiment that this takes place under those particular circumstances under which nitrification goes on in nature.

In a paper read to the French Academy in November, 1855, M. Cloez details experiments made by passing air, carefully freed from organic matters and from ammonia, through porous substances of different kinds, (pounded bricks, broken earthenware, &c.,) impregnated with potash and lime. After a certain time nitrates were found to have been generated. These experiments attracted a good deal of attention, and they have been repeated and some additional observations made.

Though we have the fact of the production of nitrates from atmospheric nitrogen clearly shown, we have still to settle the question as to what is the modus operandi of the transformation—a point which is not so simple as it might seem at first sight to be. While there are several compounds of nitrogen and oxygen, none of them can be formed by the direct union of these elements. They are derived in one way or another from the decomposition of nitric acid or of the nitrates; and in the case of the nitrates themselves, it does not appear that they can be produced by the direct combination of nitrogen,

* In 1775, a prize being offered by the French government for an essay on nitrification, a large number of papers on the subject were received and referred to a commission of the Academy. From these, and from the proceedings of the commission, Longchamp drew most of his facts. The substance of them is found in "Les Memoires des Savans divers," vol. xi.

oxygen, and a metal.* Viewing the subject by the aid of such lights as science affords, the hypothesis which appears to be best in accordance with the facts known concerning the combination of oxygen and nitrogen is that propounded by Dr. G. C. Schœffer, which is based upon that general chemical action by which various bodies assume the elements of water in such a way as to produce salts of ammonia. This action takes place very commonly with those substances which are produced *from* ammoniacal salts by the *separation* of the elements of water, and may be effected under the influence either of acid or of alkalies, and sometimes by the action of water alone at a high temperature.

Nitrous oxide (N O) will generate the nitrate of ammonia by the assumption of the elements of water; for, by the action on it of water and potash, at an elevated temperature, ammonia is evolved and nitrate of potash formed, showing that there has been a production of nitrate of ammonia and a subsequent decomposition of it by the potash.† Supposing nitrogen to act in the same way, viz: to assimilate four equivalents of water,‡ it will form *nitrate* of ammonia, which, by a well known tendency of the nitrates, will pass into the condition of a nitrate. If potash be present, the nitrate of potash will be produced by decomposition of the ammoniacal salt, and the ammonia set free may be itself nitrified. Without going into theoretical discussion, this hypothesis may be alluded to as one arrived at by legitimate analogies, and which it would be interesting and useful to test by experimental investigations. The foregoing being considered as a brief sketch of the known laws of nitrification and of one or two of the most important speculations on the subject, we may now glance at the various circumstances under which the process goes on in nature on a scale of economic importance.

II. The most important of the sources of nitre is the nitiferous soil of Hindostan, where the earth in certain districts becomes impregnated with the nitrates of lime and of potash, chiefly the latter. This takes place during the dry season, when the ground, which has been flooded by previous rains, is subjected to uninterrupted evaporation. During the rains, a large amount of organic matter must be washed down into the earth and there undergo decomposition.

Now we may suppose that the ammonia rising to the surface undergoes nitrification after the manner pointed out by Kuhlmann,§ or that its oxidation takes place at a considerable depth, in a way similar to that of the cases instanced by Dr. Smith.‖ In either case, the nitrates

* A way of trying this would be by modifying the experiment of Cavendish so as to pass the electric spark through perfectly dry air confined in a tube with metallic potassium or its oxide.

† There are numerous substances which are formed from salts of ammonia by the separation of the elements of water, and which will regenerate the salt by reassuming them. They are known to chemists as amids, anhydrids, or nitryls.

‡ The action consists in the assumption of the water by two equivalents: of the nitrous oxide in one case, and of the nitrogen in the other. In the case of nitrous oxide it may be represented thus: $N_2 O_2 + H_4 O_4 = NO_6 NH_4$; and in the case of nitrogen, $N_2 + H_4 O_4 = NO_4 NH_4$.

§ See page 306.

‖ See page 307.

would accumulate on the surface by reason of the continued evaporation going on there, a process which tends to draw up soluble matters of all sorts from below, and to deposit them above; for the water, as it evaporates, leaves behind it the non-volatile substances dissolved in it, and, after evaporation, is replaced by fresh fluid from the deeper and moister parts of the ground, which brings with it fresh supplies of soluble matter. Either of the modes mentioned will account for the formation of the nitrates, supposing their origin to be from organic matter, and will account for any case in which they accumulate on the surface of the ground during dry and warm weather.

In various other countries the soil, in certain localities, becomes impregnated with considerable quantities of nitrates. This is the case in Persia, in Egypt, in Hungary,* and in Spain. The product is of less importance than that of Hindostan, and the explanation of it probably depends upon the same principles.

The production of nitre in the open air, in such quantities as to be of value, only takes place under particular circumstances, but in *caves* a considerable amount of nitrates is often produced. The earth covering the floor of caverns containing ammonia-producing matters as well as mineral salts, the oxidation of the ammonia into nitrates takes place wherever the air is not entirely stagnant; and being protected from the rain, the nitrates will accumulate, until, after a series of years, the quantity becomes considerable. Longchamp remarks, that the earth in caves nitrifies itself sufficiently for extraction in eight or ten years. Whether we suppose the nitrates to be produced entirely from ammonia or not, the conditions furnished by a cavern, of protection from the weather, together with a moderate and uniform degree of moisture, will be equally operative.

In the western part of this country many caves exist, especially in the geological formation known as the cavern limestone, which have the earth on their floors impregnated with nitrates.† The most noted of these is the Mammoth Cave of Kentucky. During the war of 1812 they were pretty industriously worked for nitre, and, it is said, in large part exhausted. What the exact amount got from them was I have no means of ascertaining; nor have I seen any systematic calculation of what is probably obtainable from them now since they have had time to re-nitrify themselves.‡ All approximative estimates of those who are best informed put it down at but a fraction of the present annual consumption;§ but on this point I speak more from

* Nitre is found in Hungary in large quantity, mostly in boggy places, and in those subject to inundation: there is also much artificial production of it there.

† The formation of nitrates in these caves may in some part be due to a kind of nitrification described further on, (page 312) which takes place on the surface of the rock itself

‡ The nitrate produced in these caves is nitrate of lime, which has to be converted into saltpetre by the action of a solution of carbonate of potash. Having to furnish the potash adds greatly to the expense of obtaining nitre from such sources Supposing that we used commercial potash, 100 pounds of the best American ash would be required to form 133 pounds of nitrate of potash. The difficulty of supplying a sufficiency of potash became a serious obstacle in the working of these caves. The wood which grew near the scene of operations was burnt in large quantity, and the ley extracted from its ashes used. Here, however, this impediment arose, that the country being, for the most part, purely limestone, the ashes of plants growing there are much less rich in potash than in lime.

§ I have heard the amount estimated at 150,000 pounds.

general impression than from positive knowledge. It is not to be forgotten that this is a crop which, when once reaped, it will take years to renew.

Probably the best mode of managing these caves, in view of a national emergency, would be to carry into them quantities of a nitrifiable earth, preferably one arising from the decomposition of a feldspathic rock, and to leave it there until a serious call for nitre should arise.

The earth of caverns is nowhere worked as a source of nitre to a very important extent; but a formation of nitrates, which goes on under circumstances somewhat similar to those prevailing in caves, is in Europe one of the chief indigenous modes of production. In old buildings, especially in cellars and in damp outhouses, nitrate of lime is found largely in the mortar, the plaster, and sometimes in a porous limestone which has been used as a building material. We have here, as in caves, a protection from rain, and a moist atmosphere; there is also, however, in many cases a particular exposure to the emanations from decaying organic matters, as in the cellars and foundations of buildings in a badly-drained soil. The decay of walls from the formation of nitrates is known as the saltpetre rot, (saltpetre frass.) The French, during the wars of the revolution, were greatly indebted to this source for their supply of saltpetre.

A rather unique nitre formation is that of South America, where nitrate of soda, a salt not occurring largely elsewhere, is found in immense quantities. In the desert of Atacama, which lies on the western slope of the Andes, at the boundary between Peru and Chile, it forms beds of from two to three feet in thickness, in which it is mixed with various impurities.* It is also diffused through the soil over a large extent of ground. Other parts of the desert are covered with an efflorescence of saline matters, chiefly of sulphate of soda.†

The nitrate of soda has been long known in commerce under the names of cubic nitre and of Chile saltpetre, and being cheaper than nitrate of potash, has been largely used for the manufacture of nitric acid, and for other purposes where a nitrate is required.‡ It is too deliquescent to be readily used as an ingredient of gunpowder, but, like the other nitrates, it can be converted into saltpetre by the action of a salt of potash.

If it were desired to get a large quantity of a nitrate at once, the nitrate of soda would be the most available, being ready formed and accumulated to an immense extent. It is not certainly known whether the production in these South American beds is continuously going on, or whether the nitrate has resulted from actions which have now ceased. Speculations as to the origin of this formation would require a detail of circumstances which it is not, perhaps, worth while entering upon.

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* Silliman's Journal, vol. 39, p. 375.

† Chemical Society's Quarterly Journal, 1855, p. 308; also Chemist, 1855, p. 345.

‡ Nitrate of soda was first carried to Europe in 1820. In 1831 it came into use, and since then has been an important article of commerce. The quantity imported into Great Britain in 1850 was about 12,000 tons. The price in 1851 was 15*s.* per cwt.—*Ure's Dict.*

There are two cases of the production of nitrates in nature which seem rather to belong to a class by themselves, or at least to have strong points of dissimilarity from any other well known instances. I allude to the nitre-bearing chalk of the basin of Paris and the nitriferous caves of Ceylon. In both localities the face of the rock, when chipped off, is found to be impregnated with nitrates, which renew themselves on the exposed surface twice a year or oftener, and sometimes appear as an efflorescence. In the French formation the product is nitrate of lime, which forms where the rock is exposed to the southward, and chiefly in hot and damp weather. The quarries have been long worked, and the annual product is said to be about 15,000 pounds.

The nitre caves of Ceylon, which are between twenty and thirty in number, are excavations in a porous rock, consisting of limestone, talc, and feldspar. The nitrates formed are those of potash, lime, and magnesia, the former predominating. Several of the caves were visited and examined by Mr. John Davy. One of them he describes particularly as a cavity of regular shape, about 200 feet long and 100 broad. In it sixteen workmen are employed during six months of the year in chipping off the face of the rock and in extracting the nitre from the stone thus collected. Each of the men pay as an annual tithe to the government a half cwt. of nitre, so that the total quantity obtained must be considerable.

In these caves, as well as in the French quarries, it is only to the depth of a fraction of an inch below the surface of the rock that the nitrates are found, and after this thin coat has been removed it requires from one to six months for the fresh surface to become impregnated. In both these instances the conditions under which nitrification goes on are very similar, taking place on the surface of a porous rock which is continually moist, and is exposed to a warm temperature, for in France the nitrates form only on a southern exposure, and mainly during summer. The action is a more rapid one than that of the ordinary nitrification of the earth in caverns, and is to be distinguished from it. The formation of nitrates on the surface of a rock is said to take place to a less extent in other localities, among them in some caves in this country, but the nitrification in our western caves appears to be, mainly at least, that of the earth on their floors.

Both the Paris chalk and the Ceylonese caves have been cited as good arguments for nitrification without access of organic matters. We may, perhaps, imagine the filtration of water charged with the products of organic decomposition into the rock, and it has been supposed by some that the nitrogen of the animal remains which are contained in limestone may become a source of nitrates. There is one point, however, to be noted in regard to the nitriaries of the Seine: that the chips of stone, after being lixiviated, are heaped up into walls, on the surface of which the nitrate forms as on the rock itself. This seems to point to the texture of the rock as the cause of nitrification rather than any supply of organic matter.

III. Such are the different circumstances under which nitrates are produced in nature. An artificial mode of nitrification has been long practiced, and on the continent of Europe a large amount of labor and attention has been bestowed upon it.*

The general plan has been already alluded to, (page 306, note.) It consists in mixing earth, old mortar, and rubbish of various kinds with animal matters, (stable manure, &c.,) making the whole into heaps called nitre beds, and keeping these exposed to the air and moderately moist until nitrification is completed. This is practiced, under many variations of detail, in different places. The most perfect system seems to be the Prussian, according to which the mass is made into walls, which are steep on one side and cut into steps on the other. The tops of these steps are made into gutters, in which water is poured which percolates the wall and evaporates from the opposite or vertical side. On that side, of course, the nitrates accumulate and effloresce, and the earth from it being scraped off from time to time, is leached for the purpose of extracting them. While this is done, fresh material is added to the steps, so that the size and shape of the wall is preserved. In many places the materials are piled into heaps and turned over, from time to time, to expose a fresh surface to the air.

The great objection to all nitre beds I should say to be this: that while nitrates are formed on the surface, where the air has free access, in the interior of the heap the organic matters present tend to reconvert them into ammonia; and thus, between the influences of two opposing forces, the process of nitrification goes on but slowly. It is found in practice that it requires about three years for an ordinary nitre bed to become fit for extraction, and as, during that time, much labor must be bestowed upon it, and materials used that would be valuable for agricultural purposes, the utility of keeping them up has been much questioned in Europe.

The large importations of nitre from India, made in recent times, have diminished considerably the cultivation of the saltpetre plantations, as they are called, and, in fact, they are found not to be remunerative under present circumstances, and are too slow in their operation to serve as a provision against sudden emergencies. If, instead of making these heaps, the ammoniacal exhalations from the organic matters were made to pass, duly mixed with air and moisture, into a porous earth or other nitrifiable mass, the transformation would, in all probability, be much more rapid.

IV. We may now inquire what better modes of artificial nitrification are suggested by our present knowledge of the nature of the process and by the industrial means at our command. The various possible plans divide themselves into two general classes: first, those which involve the oxidation of ammonia; and second, those which depend upon the fixation of the nitrogen of the air. The first of these more especially demands our attention, as being of more certain feasibility,

* In Sweden every peasant is obliged to maintain a nitre bed, and to furnish a certain amount to the government.

or at least as requiring less recondite investigations to bring them into practical operation. We know of various plans by which the conversion of ammonia into nitrates has been effected, and can devise many more by which, in all probability, it would be effected. The first point to be considered, in connexion with this, is the means of supplying ammonia.

Ammonia is largely produced in the manufacture of coal gas, from which, after leaving the retorts, it is removed; partly by condensation as ammoniacal liquor; partly by a sort of mechanical entanglement in the lime purifier; and sometimes by the agency of water, with which the whole body of gas is washed; and sometimes, also, a special purifier is used for the ammonia, whose presence in the gas is injurious. The ammoniacal liquor is sometimes used for the manufacture of compounds of ammonia, sometimes as a manure, but frequently is allowed to run to waste. From the amount experimentally obtained from coal, it has been estimated that the ammonia producible from one ton would form about seven pounds of sulphate of ammonia.* If the ammonia in this were nitrified it would produce 10.71 pounds of saltpetre. This amount of ammonia is probably not all produced from coal by the ordinary distillation for gas, and what is evolved is in large part not collected.

The cheapest of the salts of ammonia in use is the sulphate, which costs eighty or ninety dollars a ton; a large part of which cost is that of the sulphuric acid used in its manufacture. A ton of this, if used for the production of saltpetre, would produce about 3,300 pounds of the latter. A rectified ammoniacal liquor, at one time sold in England, afforded ammonia at one-third of the expense incurred by buying it in the form of the sulphate. It was obtained by distilling the liquor of the gas-works, but never came into general use.

The sulphate of ammonia is used largely as a nitrogenous manure, and for this purpose the ammoniacal liquor itself is not very available since most of it is produced during the winter, when it cannot be applied to land, and the ammonia being volatile cannot easily be kept, unless it is converted into a non-volatile compound.

For the purpose of generating nitre the ammoniacal liquor could be used as fast as produced, either being condensed into a portable bulk for transportation or used on the spot. That part of the ammonia which escapes condensation in the gas liquor may be removed from the gas by various methods, one of which now in use is that of

* Analysis by J. C. Wrightson. Estimates of the ammonia obtainable from coal are, many of them, considerably greater than this; but some assertions that have been made with regard to the large amounts of this and of other products got from coal by certain methods of distillation are to be received with suspicion. The assumption that all the nitrogen contained in coal is given off as ammonia during distillation must be altogether erroneous, and only deserves mention because it has recently been advanced, apparently without suspicion of its fallacy. Thus we find upon such grounds the extravagant estimate made that one ton of coal will produce a hundred weight of sulphate of ammonia.—(Chemist, 1855, p. 339.) Taking the estimate which I have given in the text, the gas-works of the city of London produce enough ammonia for the formation of about 2,000 tons of saltpetre annually.

Mr. Croll, in whose purifier sulphuric acid is used for the purpose of combining with the ammonia. This has been adopted by various gas-works in London, where several tons of sulphate of ammonia are said to be produced by it daily.*

There are certain plans that, as far as I know, have never been tried, some one of which would, in all probability, be the most convenient for the purpose of removing ammonia from gas, with a view to the subsequent production of nitre from it. These involve the use of substances which form ammoniacal compounds easily decomposible by heat, such as phosphate of magnesia or boracic acid.

Ordinary animal matters, in their moist state, furnish enough ammonia for the production of from one-fourth to one-third of their weight of saltpetre. The most ancient mode of obtaining an ammoniacal compound is that practiced in Egypt, which consists in the distillation of the soot which arises from the combustion of the dried dung of animals. Ammonia is also made by the destructive distillation of bones and of other animal matters, such as blood, scraps of hide, &c. When bones are used, bone charcoal is got as residue, and other animal substances yield a charcoal which is used for the manufacture of Prussian blue. Ammonia is evolved from animal matter either by distillation or by spontaneous decomposition, and much that is now refuse might be utilized by a properly-arranged system of nitrification. The distillation of peat has lately become a source of the salts of ammonia.

We may, in brief terms, say that the production of ammonia is from cheap and abundant sources, and that the supply is capable of being augmented on occasion to any amount required.

The means of oxidizing ammonia into the condition of a nitrate may be considered under two heads:

1st. Those which depend upon the direct action of the oxygen of the air under such conditions as are alluded to on page 306, or under some modification of them. The general principles of this mode require no comment here.†

2d. Those in which substances are used, termed carriers of oxygen, that take up oxygen from the air, and part with it to the body to be oxidized. Thus the deutoxide of manganese, under the influence of heat, will give up a part of its oxygen to ammonia, converting it into a nitrate; and the reduced oxide, on being heated, with exposure to the air, will resume oxygen and pass again into the condition of a deutoxide, which can be used for the conversion of fresh ammonia, and so on, the same oxide being, in this way, used continuously. Kuhlmann, whose researches have already been noticed, proposed, after experiments on the subject, the use of the deutoxide of manga-

* In this country the gas-works throw away the ammonia even of the ammoniacal liquor. At least that is the case in those of Philadelphia, one of the largest and best conducted.

† A patent was taken out in England, in 1852, for the conversion of ammonia into a nitrate by the agency of porous bodies, of which a variety are specified, (spongy platinum, &c.) At the same time, of course, a base, such as potash, was to be used for the purpose, as it was expressed, of fixing the nitric acid. The patent did not certainly involve any principle previously unknown, nor does it appear that the patentee had an experimental knowledge of the value of any particular mode of procedure.

nese in this way for the purpose of supplying saltpetre in the event that France should be engaged in a war which should cut her off from foreign sources of this necessary article. Other substances, deutoxide of barium, &c., have the same property with deutoxide of manganese.

There is one body which has been found to have remarkable power in bringing about the oxidation of ammonia, the precise mode of whose action may be a little doubtful. According to the experiments of Mr. Ashe, when the vapor of ammonia, mixed with air, comes into contact with freshly-prepared sesquioxide of chromium, it undergoes such rapid oxidation that the oxide glows and remains red hot until the ammonia is consumed. This takes place not only with ammonia, but with many other combustible vapors.*

Mr. Ashe supposes the rationale of this action of the chrome oxide to be the same as in the similar case of spongy platinum—to depend, in other words, upon the physical condition of great porosity, and this is, undoubtedly, the main cause, but possibly the chrome acts also as a carrier of oxygen by passing alternately from a higher to a lower degree of oxidation. However that may be, this employment of the oxide of chromium deserves attention, as promising to furnish a most excellent mode of nitrification.

The second mode of producing nitrates (by the combination of the elements of the atmosphere) is one which has experimentally been shown to be possible, and which probably goes on upon a large scale in nature in conjunction with the first-mentioned method. The economy of a manufacture based on this mode, if it could be brought into extensive operation, is very apparent; but the subject has been so imperfectly investigated as yet, that what could be said upon its feasibility would be merely conjectural.

V. The fifth and concluding branch of the topic is this: By what means may experimental science best be advanced in regard to the subject of nitrification?

It must strike every one that, considering the importance of the subject and the length of time during which an interest has been felt in it, our actual knowledge of it is remarkably limited. Dumas remarks, in this connexion, that such a length of time and so much trouble would be required to watch the process as it goes on in nitre beds, that no one has had the courage to undertake it; and the same thing holds, to a great extent, with regard to the study of nitrification under any aspect. Within the last twenty-five years experiments have been made from time to time that have thrown light on particular points; and occasional observations upon the natural production of nitre have given us something to build conjecture upon, but inquiries of either kind have generally not been pushed beyond the isolated fact in which they began, but have stopped after showing that a nitrate might be generated in some particular way, or describing some locality in which it was found. Even such contribu-

* Lond. Ed. and Dub. Ph. Jour., 1853.

tions to our knowledge have not been frequent, and most of what has been done in an experimental way has been in connexion with researches in agricultural chemistry.

In a subject so complicated, involving the solution of so many questions, each of which by itself is but an inconsequential step towards a complete theory, the demonstration of a few detached truths does not seem to be a satisfactory return for any great labor or expense, and no one could think of taking it up in a thorough way without a greater command of time and means than is usually possessed by chemists. The most important drawback to a determination of proper means for the artificial production of saltpetre is to be found in the want of a stimulus from manufacturing enterprise. All such manufacture has been greatly discouraged of late years by the large importations from India and South America; and the prospect of any considerable and permanent rise in prices is too remote to be the occasion of speculation or outlay.

We have, indeed, every reason to believe that if a certain amount of progress were once made in the matter it would become an important and profitable branch of industry, under all circumstances; but new methods of manufacture generally owe their development not to their promise of future usefulness, but to the pressure of some immediate want.

At present, the subject of nitrification is of interest, not so much to the practical chemist, who seeks for some easy step to immediate profit, as to the statesman, who looks forward to times of national emergency, when nitre shall become an article of vital necessity, and the usual modes of obtaining it be cut off. This country is so situated as to make this a matter of peculiar interest. No other nation, perhaps, can in any war in which it is likely to be engaged be so completely deprived of this important article. We have no saltpetre plantations in actual operation, not many buildings whose walls we could expect to find much nitrified, and our only natural resource is one which, we have every reason to believe, would be a very insufficient one, viz: that of our western caves.

Great Britain could, in a war with us, very easily stop our importation of saltpetre from her own possessions in Hindostan, and that of nitrate of soda from the few ports of South America whence it can be obtained, and could check, to a great extent at least, attempts on our part at getting supplies from Europe. While we could be severely pressed in this way by a single power, a combination against us would increase our isolation, and call on us for still more exhausting efforts. To provide against such contingencies is, indeed, a thing entirely practicable.

While modern warfare calls for enormous expenditures of saltpetre, modern science has the power of finding means for a corresponding production. But this power, to become available, must be studied; and its study, which the ordinary course of peaceful events gives no stimulus to, should be the especial care of government, as one of the most important means of providing for the common defence. Not only should principles be established, but details should be de-

termined on, and some adequate system of operations should be at least sketched out, even if not brought into present practice. To do this will not be the work of a day, nor, perhaps, of a year; it will require thought and labor, as well as enterprise, and it should not be left to a time of hurry and emergency.

I respectfully submit the above paper, hoping that it may be of some assistance towards the desired object. In it I have sought rather to give a statement of the different questions to be considered than to enter into lengthy discussions of them. If a fuller detail should be desired on any particular branch of the subject, I shall be happy to do whatever lies in my power towards furnishing it, but I am strongly inclined to think that reliable conclusions on those points that I have left untouched or unsettled can hardly be attained by any other means than those of original investigation.

NOTE BY THE AUTHOR.—A great obstacle to the cheap artificial production of nitrate of potash is the high price of the potash which must be used in its manufacture.

The nitrates of soda, of lime, and of magnesia, which can be more cheaply obtained than ordinary nitre, have not heretofore been used in the manufacture of gunpowder, for the reason that they have a strong tendency to absorb water, and to render damp the powder into whose composition they enter.

Of late years, however, water-proof cartridges of various kinds have been brought into use, and it would be perfectly feasible to employ in these gunpowder made from the more deliquescent nitrates.

Solid blocks of gunpowder with a water-proof coating of collodion are said to have been tried with good results in both cannon and small arms; and if this, or any equivalent contrivance, should be introduced into our military service, it would, by facilitating the use of the cheaper nitrates, open a way through which we might render ourselves less dependent upon foreign countries for a very essential material of war.

One of the various things which it may be recommended to the government to do is, to have made and tried gunpowder, manufactured from the nitrate of soda, and put up in water-proof cartridges, or in collodion-covered blocks.

NOTES ON THE HISTORY OF PETROLEUM OR ROCK OIL.

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(From the Canadian Naturalist and Geologist.)

PUBLIC attention has lately been drawn to the petroleum furnished by the oil wells in Canada and the United States, and we have therefore thought it well to bring together some few facts which may serve to explain the origin of this and of similar substances, including naphtha, petroleum or rock oil, and asphalt or mineral pitch, all of which are forms of bitumen, the one being solid and the others fluid at ordinary temperatures. These differences are, in many cases at least, due to subsequent alterations; the more liquid of these substances are mixtures of oils differing in volatility, and by exposure to the air become less fluid, and partly by evaporation, partly by oxidation from the air, eventually become solid and are changed into mineral pitch. These substances, which are doubtless of organic origin, occur in rocks of all ages, from the lower silurian to the tertiary period inclusive, and are generally found impregnating limestones, and more rarely, sandstones and shales. Their presence in the lower palæozoic rocks, which contain no traces of land plants, shows that they have not been in all cases derived from terrestrial vegetation, but may have been formed from marine plants or animals; the latter is not surprising when we consider that a considerable portion of the tissues of the lower marine animals is destitute of nitrogen, and very similar in chemical composition to the woody fibre of plants. Besides the rocks which contain true bitumen, we have what are called bituminous shales, which, when heated, burn with flame, and by distillation at a high temperature yield, besides inflammable gases, a portion of oil not unlike in its characters to petroleum. These are, in fact, argillaceous rocks intermixed with a portion of organic matter allied to peat or lignite, which, by heat, is decomposed and gives rise to oily hydrocarbons. These inflammable or lignitic shales, which may be conveniently distinguished by the name of *pyroschists*, (the *brandschiefer* of the Germans) are to be carefully distinguished from rocks containing ready-formed bitumen; this being easily soluble in benzole or sulphuret of carbon can be readily dissolved from the rocks in which it occurs, while the pyroschists in question yield, like coal and lignite, little or nothing to these liquids.

It is the more necessary to insist upon the distinction between lignitic and bituminous rocks, inasmuch as some have been disposed to regard the former as the source of the bitumen found in nature, which they conceive to have originated from a slow distillation of these matters. The result of a careful examination of the question has, however, led us to the conclusion that the formation of the one ex-

cludes more or less completely that of the other, and that bitumen has been generated under conditions different from those which have transformed organic matters into coal and lignite, and probably in deep water deposits, from which atmospheric oxygen was excluded. Thus in the palæozoic strata of North America we find in the Utica and Hamilton formations highly inflammable pyroschists, which contain no soluble bitumen, and the same is true to a certain extent of some limestones, while the Trenton and Corniferous limestones of the same series are impregnated with petroleum or mineral pitch, and, as we shall show, give rise to petroleum springs. The fact that intermediate porous strata of similar mineral characters are destitute of bitumen, shows that this material cannot have been derived from overlying or underlying beds, but has been generated by the transformation of organic matters in the strata in which it is met with. This conclusion is in accordance with that arrived at by Mr. S. P. Wall, in his recent investigations in Trinidad. He has shown that the asphalt of that island and of Venezuela belongs to strata of the tertiary formation, (of upper miocene or lower pliocene age,) which consist of limestones, sandstones and shales, associated with beds of lignite. The bitumen is found not only in the famous pitch lake, but *in situ*, where it is confined to particular strata, which were originally shales containing vegetable remains; these have undergone "a special mineralization producing a bituminous matter instead of coal or lignite. This operation is not attributable to heat, nor of the nature of a distillation, but is due to chemical reactions at the ordinary temperature, and under the normal conditions of climate." He also describes wood partially converted into bitumen, which last, when removed by solution, leaves a portion of woody tissue.—(Proc. Geol. Soc. London, May, 1860.)

The sources of petroleum and mineral pitch in Europe and in Asia are for the most part like those just named, confined to rocks of newer secondary and tertiary age, though they are not wanting in the palæozoic strata, which in Canada and the United States furnish such abundant supplies of petroleum. In the great palæozoic basin of North America bitumen, either in a liquid or solid state, is found in the strata at several different horizons. The forms in which it now occurs depend in great measure upon the presence or absence of atmospheric oxygen, since by oxydation and volatilization the naphtha or petroleum, as we have already explained, becomes slowly changed into asphalt or mineral pitch, which is solid at ordinary temperatures. It would even appear that by a continuance of the same action the bitumen may lose its fusibility and solubility, and become converted into a coal-like matter. Thus in the calciferous sandrock in New York a black substance, which has been called anthracite, occurs in cavities with crystals of bitter spar and quartz. It sometimes coats these crystals or the walls of the cavities, and at other times appears in the form of buttons or drops, evidently, according to Mr. Vanuxem, having been introduced into these cavities in a liquid state, and subsequently hardened as a layer above the crystals, which have conformed to them, showing that this coal-like matter was once in a plastic

state. It is very pulverulent, brittle, of a shining black, and according to Vanuxem yielded but little ash, and 11½ per cent. of volatile matter, which he regarded as water, (Vanuxem, Geology of New York, iii, 33.) A similar material occurs in the Quebec group in Canada, the equivalent of the calciferous sandrock, and fills cavities and fissures in the limestones, sandstones, and even in the accompanying trap rocks, as at Quebec, Orleans island, Point Levis, and at Acton, presenting mamillary surfaces as noticed by Vanuxem, which evidently show that it has once been semi-fluid. This matter from the first two localities is completely infusible, and insoluble in benzole; it readily crumbles between the fingers and gives a very black powder. When exposed to a high temperature it gives off abundance of inflammable strong-smelling vapors, which condense into a tarry oil, and leave a black residue, which when heated slowly burns away, leaving only a trace of ash. The volatile portion is equal to from 19.5 to 21.0 per cent. The mineral from the Acton copper mine is much harder and less friable, and approaches to anthracite in its characters. When heated it gives off watery vapor without any bituminous odor. Its loss by heat was 6.9 per cent., and the residue of ash was equal to 2.2 per cent.

An evidence of the presence of unaltered petroleum in almost all the Lower Silurian limestones is furnished by the bituminous odor which they generally exhibit when heated, struck, or dissolved in acids. In some cases petroleum is found filling cavities in these limestones, as at Rivière à la Rose (Montmorenci,) where it flows in drops from a fossil coral of the Birdseye limestone, and at Pakenham, where it fills the cavities of large orthoceratites in the Trenton; from some specimens nearly a pint of petroleum has been obtained; it is also said to occur in the township of Lancaster in the same formation. The presence of petroleum in the Lower Silurian rocks of New York is shown in the township of Guilderland, near Albany, where, according to Beck, considerable quantities of petroleum are collected upon the surface of a spring which rises through the Hudson river or Loraine shales. On the Great Manitoulin island, also, according to Mr. Murray, a petroleum spring issues from the Utica state, and he has described another at Albion Mills, near Hamilton, rising through the red shales of the Medina group; these have probably their origin in the Lower Silurian limestones, which may in some localities prove to be valuable sources of petroleum.

In the Upper Silurian and Devonian rocks bitumen is much more abundant. Eaton long since described petroleum as exuding from the Niagara limestone; and this formation throughout Monroe county, in western New York, is described by Mr. Hall as a granular crystalline dolomite including small laminæ of bitumen, which give it a resinous lustre. When the stone is burned for lime the bitumen is sometimes so abundant as to flow like tar from the kiln. In the corniferous limestone at Black Rock, on the Niagara river, petroleum is described as occurring in cavities, generally in the cells of fossil corals, from which, when broken, it flows in considerable quantities.

It also occurs in similar conditions in the Cliff limestone (Devonian) of Ohio.

Higher still in the series, at the base of the Hamilton group, occur what in New York have been called the Marcellus shales; these enclose septaria or concretionary nodules which contain petroleum, while at the summit of the same group similar concretions holding petroleum are again met with. The sandstones of the Portage and Chemung group in New York are in many places highly bituminous to the smell, and often contain cavities filled with petroleum, and in some places seams of indurated bitumen. A calcareous sandstone from this formation at Laona, near Fredonia, in Chatauque county, contains more than two per cent. of bituminous matter. At Rockville, in Alleghany county, according to Mr. Hall, the same sandstones are highly bituminous and give out a strong odor when handled, and in the counties of Erie, Seneca, and Cattaraugus abundant oil springs rise from the sandstones, and have been known to the Seneca Indians from ancient times. In the northern part of Ohio, according to Dr. Newberry, petroleum is found to exude in greater or less quantity from these sandstones wherever they are exposed, and the oil wells of Pennsylvania and Ohio are sunk in these Devonian sandstones, often through the overlying carboniferous conglomerate, and in some cases apparently, according to Newberry, through the sandstones themselves, which are supposed by him to be only reservoirs in which the oil accumulates as it rises through fissures from a deeper source; in proof of which he mentions that in boring wells near to each other the most abundant flow of oil is met with at variable depths. In some instances the petroleum appears to filter slowly into the wells from the porous strata around, which are saturated with it, while at other times the bore seems to strike upon a fissure communicating with a reservoir which furnishes at once great volumes of oil. An interesting fact is mentioned in this connexion by Mr. Hall. In the town of Freedom, Cattaraugus county, New York, is a spring which had long been known to furnish considerable quantities of petroleum. On making an excavation about six yards distant, to the depth of fourteen feet, a copious spring of petroleum arose, and for some time afforded large quantities of oil; after which the supply diminished in both the old and new springs, so that it is now less than at the first settlement of the country. Notwithstanding its general distribution throughout a considerable region in the adjacent portions of New York, Pennsylvania, and Ohio, it is only in a few districts that it has been found in quantities sufficient to be wrought with profit. The wells of Mecca, in Trumbull county, Ohio, have been sunk from 30 to 200 feet in a sandstone which is saturated with oil; of 200 wells which have been bored, according to Dr. Newberry, a dozen or more are successfully wrought, and yield from five to twenty barrels a day. The wells of Titusville, on Oil creek, Pennsylvania, vary in depth from 70 to 300 feet, and the petroleum is met with throughout. The oil from different localities varies considerably in color and thickness, and in its specific gravity, which ranges from 28° to 40° Baumé, (from .890 to .830.)

The valley of the Little Kanawha, in Virginia, which is to be looked upon as an extension of the same oil-bearing region, contains petroleum springs which, so long ago as 1836, according to Dr. Hildreth, yielded from fifty to a hundred barrels yearly. It here rises through the carboniferous strata, and, as elsewhere, is accompanied by great quantities of inflammable gas.

The black inflammable shales of the Devonian series in western Canada, which were formerly referred to the Hamilton group, and are now considered to belong to the base of the overlying Portage and Chemung, appear at Kettle Point, on Lake Huron, and in portions of the region southward to Lake Erie; but the oil wells sunk in Enniskillen show that the source of the oil is really below the horizon of these shales, inasmuch as the underlying argillaceous shales and limestones of the Hamilton group are there found near the surface, and have been penetrated 120 feet, at which depth oil is still met with, leaving but little doubt that it is derived from the limestones beneath, which both in New York and in Canada are impregnated with petroleum. A somewhat slaty brownish-black bituminous dolomite belonging to the corniferous limestone from Pine creek, near Alma, in Kincardine, gave me not less than 12.8 per cent. of bitumen, fusible and readily soluble in benzole, and another from the Grand Manitoulin island, which was a brown crystalline dolomite, yielded from 7.4 to 8.8 per cent. of similar bitumen. The solid form of this bitumen at the outcrop of the rocks is probably due to the action of the air.

The existence of liquid bitumen in the corniferous limestone in western Canada was pointed out as long ago as 1844 by Mr. Murray, who tells us that this rock is generally bituminous, and that cavities in it are often filled with petroleum; the quarries near Gravelly bay, in Wainfleet, are cited as an example.—(Report of Geological Survey, 1846, p. 87.) In the report for 1850 we find a notice of what are called oil springs, in which petroleum rises to the surface of the water near the right bank of the Thames, in Mosa, and in two places on Bear creek, in Enniskillen. Subsequently Mr. Murray described a considerable deposit of solid bitumen or mineral tar, which occurs in the same township, extending over about half an acre, and in some places two feet in thickness, doubtless formed by the drying up of petroleum springs.—(Report for 1851, p. 90.) I had already, in the report for 1849, p. 99, described this bitumen from specimens in the Museum of the Geological Survey, and called attention to its economic applications, remarking that "the consumption of this material in England and on the continent for the construction of pavements, for paying the bottoms of ships, and for the manufacture of illuminating gas is such that the existence of these deposits in the country is a matter of considerable importance." At this time solid bitumen was thus employed, but in the liquid form of petroleum its use was chiefly confined in Europe to medicinal purposes. Under the names of Seneca oil and Barbadoes tar it had long been known and employed medicinally by the native tribes of America. Its use for burning, as a source of light or heat, in modern times has been chiefly confined to

Persia and other parts of Asia, although in former ages the wells of the Island of Zante, described by Herodotus, furnished large quantities of it to the Grecian Archipelago, and Pliny and Dioscorides describe the petroleum of Agrigentum, in Sicily, which was used in lamps under the name of Sicilian oil. The value of the naphtha annually obtained from the springs at Bakoum, in Persia, on the Caspian sea, was some years since estimated by Abich at about $600,000, and the petroleum wells of Rangoon, in Burmah, are said to furnish not less than 400,000 hogsheads yearly. In the last century the petroleum or naphtha obtained from springs in the Duchy of Parma was employed for lighting the streets of Genoa and Amiano. But the thickness, coarseness, and unpleasant odor of the petroleum from most sources were such that it had long fallen into disuse in Europe, when in 1847 the attention of Mr. Young, a manufacturing chemist of Glasgow, was called to the petroleum which had just been obtained in considerable quantities from a coal mine at Riddings, in Derbyshire, from which, by certain refining processes, he succeeded in preparing a good lubricating oil. This source, however, soon becoming exhausted he turned his attention to the somewhat similar oils which Reichenbach and Selligue had long before shown might be economically obtained by the distillation of coal, lignite, peat, and pyroschists. To this new industry Mr. Young gave a great impetus, and in connexion with it attention was again turned to the refining of liquid and solid bitumens, it being found that the latter by distillation gave great quantities of oils identical with those from petroleum. About the year 1853 the attention of speculators was turned to the deposits of bitumen in Enniskillen, just described, but it was not till 1857 that Mr. W. M. Williams, of Hamilton, with some associates, undertook the distillation of this tarry bitumen, when they soon found that by sinking wells in the clay beneath it was possible to obtain great quantities of the material in a fluid state. Large numbers of wells were subsequently sunk by Mr. Williams and others in the southern part of the township of Enniskillen, along the borders of Black creek, and also about ten miles further north on Bear creek. Nearly one hundred wells had been sunk when I visited the place in December last, and many more have since been bored. Of these but a small proportion furnish available quantities of oil, but the whole amount already obtained from the district is perhaps not less than 300,000 or 400,000 gallons. Owing to the difficulties of communication and of procuring casks sufficient for the oil these wells have not yet been wrought in a continuous manner; large quantities of oil are, however, taken out at intervals of some days, and it is probable that if continuously worked the supply would be still greater. Here, as in Pennsylvania, considerable variations are found in the quality of the oil; that from the wells on Black creek is more liquid and less dense than the oil from Kelly's wells on Bear creek, and it is said that wells recently sunk to a considerable depth in the rock have yielded an oil still thinner, lighter colored, and less dense, which is prized as being more profitable for refining. The present wholesale price of the crude oil from Kelly's wells, delivered at the Wyoming station on the

Grand Trunk railway, is about thirteen cents a gallon. The oil obtained by Mr. Williams is refined in Hamilton, while that from the northern part of the township has hitherto been sent to Boston, though refining works are now being erected at the wells. The process of refining consists in rectifying by repeated distillations, by which the oil is separated into a heavier part employed for lubricating machinery, and a lighter oil, which, after being purified and deodorized by a peculiar treatment with sulphuric acid, is fit for burning in lamps.

These wells occur along the line of a low broad anticlinal axis which runs nearly east and west through the western peninsula of Canada, and brings to the surface in Enniskillen the shales and limestones of the Hamilton group, which are there covered with a few feet of clay. The oil doubtless rises from the corniferous limestone, which, as we have seen, contains petroleum; this being lighter than the water which permeates at the same time the porous strata, rises to the higher portion of the formation, which is the crest of the anticlinal axis, where the petroleum of a considerable area accumulates and slowly finds its way to the surface through vertical fissures in the overlying Hamilton shales, giving rise to the oil springs of the region. The oil is met with at various depths; in some cases an abundant supply is obtained at forty feet, while near by it is only met with at three or four times that depth, and sometimes only in small quantities. Everything points to the existence of separate fissures communicating with a deep-seated source. At Kelly's wells, however, it would appear that a reservoir has been formed much nearer the surface, where in a bed of gravel and boulders, underlying the superficial clays, the oil rising from the rocks beneath has accumulated. The inflammable gas which issues from the wells is not necessarily connected with the petroleum, inasmuch as it is an almost constant product of the decomposition of organic matters, and is copiously evolved from rocks which are destitute of bitumen. It is similar to the gas of marshes and to the fire damp of coal mines. A curious circumstance is, however, noticed by Mr. Robb; the gas which accumulates in the oil pits becomes charged with vapors which produces upon the workmen a sort of intoxication like nitrous oxyd.* This is not surprising when we remember that volatile hydrocarbons, like amylene, closely related to the hydrocarbons of petroleum, produce similar effects when their vapor is respired.

The oil wells of the United States are for the most part sunk in the sandstones which form the summit of the Devonian series, but the oils of western Virginia and southern Ohio rise through the coal measures which overlie the Devonian strata, while the wells of Enniskillen are situated much lower, and are sunk in the Hamilton shales, which immediately overlie the corniferous or Devonian limestone. It is not impossible that in Ohio some of the higher strata, such as the sandstone, were originally impregnated with the bitumen, but in Canada,

* Mr. Charles Robb, C. E., has published in the Canadian Journal for July an interesting paper on the oil wells of Enniskillen, to which, as also to a paper by Prof. E. B. Andrews, of Ohio, in Silliman's Journal for July, I am indebted for several facts.

from the absence of this substance diffused through the shales in question, we are forced to assign it to a lower horizon, which is doubtless that of the bituminous Devonian limestone. This view I have for some time maintained in opposition to those who conceive the bitumen to be derived from the black pyroschists; see my lecture before the Board of Arts, reported in the Montreal Gazette of March 1, where I asserted that the source of the petroleum was to be sought in the bituminous Devonian and Silurian limestones; besides the corniferous limestone (Devonian,) we have shown that both the Niagara and the Trenton, (of Upper and Lower Silurian age,) contain petroleum. The question of the extent of the supply of petroleum is not easily answered; the oil now being wrought is the accumulated drainings of ages, concentrated along certain lines of elevation, and the experience of other regions has shown that these sources are sooner or later exhausted; but though the springs of Agrigentum, like those of Derbyshire, have nearly ceased to flow, those of Burmah and Persia still furnish, as they have for ages past, immense quantities of oil; nothing but experience can tell us the richness of the subterranean reservoirs. It is not probable that the Devonian limestone is equally rich in petroleum throughout its whole distribution, but the exposures of it in the west are too few to enable us as yet to say in what portions the petroleum predominates; as, however, this rock underlies more than one-half of the western peninsula, we may look for petroleum springs much further east than Enniskillen. A well yielding considerable quantities of petroleum is said to occur in the township of Dereham, about a quarter of a mile southwest of Tilsonburg, and we may reasonably expect to find others along the line of the anticlinal, or of the folds which are subordinate to it.

It is now many years since Sir William Logan described the occurrence of petroleum springs in Gaspé, and collected specimens of the oil, which are preserved in the Geological Museum. One of these, near Gaspé bay, is described as occurring on the south side of the St. John's river, about a mile and a half above Douglastown, where it may be collected by digging pits in the mud on the beach. Another locality is about 200 yards up a small fork of the Silver brook, which falls into the southwest arm six or seven miles above Gaspé basin. The oil collects in pools along the stream, and may be gathered in considerable quantities. The cavities in a greenstone dyke on Gaspé bay were also found to be filled with petroleum, and the odor of it from the rock was perceived at a considerable distance. The dyke, which marks a fold in the stratification, runs in the direction of the petroleum springs, and the evidences of the distribution of petroleum are thus, as Sir William Logan has remarked, visible along a line of twenty miles.—(Report for 1844, p. 41.) Attention has recently been drawn to these indications, and a company formed, with a view of exploring this region for petroleum. Here, as well as in western Canada and the United States, the connexion is evident between the springs and undulations of the strata which favor the accumulation of the petroleum.

SUPPLEMENTARY NOTE.

We have stated in the preceding paper that the different mineral combustibles have been derived from the transformations of vegetable matters, or in some cases of animal tissues analogous to these in composition. The composition of woody fibre or cellulose, in its purest state, may be represented by $C_{24}H_{20}O_{20}$, or as a compound of the elements of water with carbon; the incrusting matter of vegetable cells, to which the name of lignine has been given, contains, however, a less proportion of oxygen and more carbon and hydrogen than cellulose, so that the mean composition of recent woods, as deduced from numerous analyses of various kinds, may be represented by $C_{24}H_{18\cdot4}O_{16\cdot4}$. We may conceive of four different modes of transformation of woody fibre, all of which probably intervene to a greater or less degree in the production of mineral combustibles; and in considering these changes we shall for greater simplicity adopt for the composition of woody fibre the first-named formula $C_{24}H_{20}O_{20}$.

I. When wood is exposed to the action of moist air, oxygen is absorbed, and carbonic acid and water are evolved in the proportion of one equivalent of the first for two of the last. We may suppose that for H_2, which is oxydized by O_2 from the air, the wood loses CO_2; so that while the carbon increases in amount, the proportions of oxygen and hydrogen are unchanged. In this way an equivalent of cellulose, by absorbing sixteen equivalents of oxygen and losing eight of carbonic acid, (8 CO_2,) and sixteen of water, (16 HO,) would leave $C_{16}H_4O_4$. Such is the nature of the decay of wood when exposed to the air, and the process, could it be carried out, would leave a residue of carbon only. If, however, the wood is deeply buried and excluded from the oxygen of the air, two reactions are conceivable.

II. The whole of the oxygen of the wood may be given off in the form of carbonic acid, while the hydrogen remains with the residual carbon. The abstraction of ten equivalents of carbonic acid from one of woody fibre would leave a hydrocarbon $C_{14}H_{20}$.

III. Instead of combining exclusively with the carbon, a part of the oxygen of the wood may be set free as water, in combination of the hydrogen. The abstraction from an equivalent of woody fibre of four equivalents of carbonic acid and twelve of water would leave a hydrocarbon $C_{20}H_8$.

IV. These decompositions are, however, never so simple, as we have supposed in II and III; for a portion of hydrogen is at the same time evolved in combination with carbon, chiefly as marsh gas, C_2H_4. The amount of this gas evolved from decaying plants submerged in water, and the immense quantities of it condensed in coal beds and other rocky strata, (forming fire damp,) show the great extent to which this mode of decomposition prevails.

In nature these various modes of decomposition often go on together, or intervene at different stages in the decomposition of the same mass; they are, besides, seldom so complete as we have rep-

resented them. The first process results in the formation of vegetable mould, which always retains portions of carbon and hydrogen; while the incomplete operation of the processes II, III, and IV, gives rise to peat, lignite, brown coal, bituminous coal, and pyroschists, in all of which the proportion of the oxygen is much less than the hydrogen, so that their composition may be approximately represented by mixtures of hydrocarbons with vegetable fibre. The following results have been selected from a great number of analyses by various chemists, and are for the most part taken from Bischof's *Chemical Geology*, (vol. I, cap. XV.) The nitrogen which, in most cases, was included with the oxygen in the analysis, has been disregarded, and the oxygen and hydrogen, for the sake of comparison, have been calculated for twenty-four equivalents of carbon.

1. Vegetable fibre or cellulose	$C_{24}H_{20}O_{20}$
2. Wood, mean composition	$C_{24}H_{18\cdot4}O_{16\cdot4}$
3. Peat, (Vaux)	$C_{24}H_{14\cdot4}O_{10}$
4. Peat, (Regnault)	$C_{24}H_{14\cdot4}O_{9\cdot6}$
5. Brown coal, (Schrötter)	$C_{24}H_{14\cdot3}O_{10\cdot6}$
6. Brown coal, (Woskresensky)	$C_{24}H_{13}O_{7\cdot6}$
7. Lignite, (Vaux)	$C_{24}H_{11\cdot3}O_{6\cdot4}$
8. Lignite, passing into mineral resin, (Regnault)	$C_{24}H_{15}O_{3\cdot3}$
9. Bituminous coal, (Regnault)	$C_{24}H_{10}O_{3\cdot3}$
10. Bituminous coal, (Regnault)	$C_{24}H_{10}O_{1\cdot7}$
11. Bituminous coal, (Regnault)	$C_{24}H_{8\cdot4}O_{1\cdot2}$
12. Bituminous coal, (Regnault)	$C_{24}H_{8}O_{0\cdot9}$
13. Bituminous coal, (Kühnert and Gräger)	$C_{24}H_{7\cdot4}O_{1\cdot3}$
14. Bituminous coal, mean composition, (Johnston)	$C_{24}H_{9}O_{2}$–O_{4}
15. Albert coal, (Wetherell)	$C_{24}H_{15\cdot9}O_{1\cdot6}$
16. Asphalt, Auvergne	$C_{24}H_{17\cdot7}O_{2\cdot2}$
17. Asphalt, Naples	$C_{24}H_{14\cdot6}O_{2}$
18. Asphalt, Bastennes	$C_{24}H_{16}O_{0\cdot7}$
19. Elastic bitumen, Derbyshire, (Johnston)	$C_{24}H_{22}O_{0\cdot3}$
20. Bitumen of Idria	$C_{24}H_{8}$
21. Petroleum and naphtha	$C_{24}H_{24}$

In the above table we see the transition from peat and brown coal to lignite, and thence to bituminous coal. Professor Johnston, from his experiments in various coals, including cannel from Wigan, splint coal from Workington, and caking coal from Newcastle, deduced the composition given in 14, in which with $C_{24}H_{9}$ the oxygen varies from two to four equivalents. It will be seen from a comparison of the infusible Albert coal with the bitumens 16, 17, and 18, how gradual is the transition to the true petroleums and naphthas, from which oxygen is absent. The asphalts also, as will be observed, differ very much in their composition, and though generally much richer in hydrogen than the bituminous coals, the variety from Naples (17,) which is completely fusible at 140° C., contains less hydrogen and more oxygen than the Albert coal analyzed by Wetherell; while the idrialine or bitumen found with the mercury ores of Idria approaches very nearly in composition to the bituminous coals 11, 12, and 13, with which many asphalts may be said to be isomeric. It is, however, probable that those oxygenized bitumens, unlike the coals, are products

of the oxydation of naphtha or petroleum by a process similar to that by which resins are derived from vegetable hydrocarbons. These formulas must be taken as representing not the true equivalents, but only the proportions of the elements in the bodies in question, which are in most cases mixtures of various substances. This is especially true of naphtha, which may be taken as the representative of pure unoxydized petroleum, and which is separated by distillation into oils of very different boiling points. The late analyses by Uelsmann of the rectified rock oil from Sehnde near Hanover, gave the formula $C_{18}H_{20}$, and according to De la Rue and Müller, the greater part of the Rangoon petroleum consists of hydrocarbons in which the number of equivalents of hydrogen is a little greater than the carbon; one gave $C_{26}H_{28}$. Associated with these are, however, portions of bodies containing a less proportion of hydrogen, so that we may conceive the mean composition of petroleum to be represented, as in the preceding table, by equal equivalents of hydrogen and carbon; many forms of solid bitumen also, as ozokerite and hatchetine, have the same general composition.

By referring to what has been said above it will be seen that the final result of the third process of decomposition of woody fibre, in which the air being excluded, the oxygen is shared between the carbon and hydrogen, would be $C_{20}H_8$. A similar result would be obtained with the simultaneous evolution of marsh gas, if we suppose $6\ CO_2 + 8\ HO + 3\ CH_2$ to be removed from an equivalent of woody fibre, leaving $C_{15}H_6 = C_{20}H_8 = C_{24}H\,9.5$, which approaches the composition of most bituminous coals and of idrialine. A further elimination of marsh gas would leave a residue of pure carbon, and thus, as Bischof has suggested, vegetable matters may be converted into anthracite without the intervention of a high temperature.

The elimination of the whole of the oxygen in the form of carbonic acid would leave a compound with a large excess of hydrogen, of which it would be necessary to remove a portion in the form of water or marsh gas in order to reduce the residue to the composition of petroleum. We know of no combination of carbon and hydrogen in which the number of atoms of hydrogen surpasses by more than two those of hydrogen, the general formula being C_nH_{n+2}, so that oils like $C_{18}H_{20}$ and $C_{26}H_{28}$ contain nearly the maximum quantity of hydrogen, and a body like $C_{14}H_{20}$, whose formation we have supposed above, could not exist, but must break up into marsh gas and some less hydrogenous oil like petroleum.

We do not know the precise conditions which in certain strata favor the production of petroleum rather than of lignite or coal, but in the fermentation of sugar, to which we may compare the transformations of woody fibre, we find that under different conditions it may yield either alcohol and carbonic acid, or butyric and carbonic acids with hydrogen, and even in certain modified fermentations the acetic, lactic, and propionic acids, and the higher alcohols, like $C_{10}H_{12}O_2$. These analogies furnish suggestions which may lead to a satisfactory explanation of the peculiar transformation by which, in certain sedimentary strata, organic matters have been converted into bitumen.

EXPLOSIBILITY OF COAL OILS.

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So recent has been the introduction of coal oil into general use for burning in lamps, that few persons have as yet had satisfactory opportunities of obtaining a knowledge either of its peculiar properties or of the peculiar processes lately invented for extracting oil from coal in quantities sufficient to constitute a new and important article of commerce.

Some of the qualities of coal oil sold in the market having proved dangerously explosive, the directors of fire insurance companies have become alarmed, and have increased the rates of fire insurance on property where such oil is stored or burnt in lamps, deeming it to be extra hazardous, like camphene and "burning fluid." But a manifest difference being discoverable in the inflammability of the oils supplied from different establishments, it is evident that some mode of distinguishing the safe from the unsafe oils has finally become indispensable for the security of the insurers as well as for the satisfaction of the insured. Accordingly, in compliance with a request of the board of directors of the Rhode Island Mutual Fire Insurance Company, the following investigations have been made to determine, by practical experiments, the comparative explosibility of coal oils, and the consequent probable danger of the use of them in lamps for lighting manufactories and dwellings.

Several of the experiments may appear to be very simple; but as they serve to exhibit instructive facts for popular information, they are none the less valuable for dispelling unfounded fears of danger, and for inducing due caution where there may exist causes for alarm.

All the liquid products of the distillation of coal are popularly considered as "coal oils;" but there is an extraordinary difference in their volatility and inflammability, from the explosive flash of volatile spirits, resembling ether and alcohol, to the dull heavy blaze of a smoking tar. The several peculiar qualities of the products of the distillation of bituminous coal will be most readily learned from a description of the processes practically adopted by the distillers for obtaining them.

The process of making common coal gas by the distillation of bituminous coal in red-hot iron retorts or ovens, set over furnaces, is well known; but it may not be generally known that before the iron retorts become heated red-hot, a tarry liquid or oil first comes over into the main gas-pipes, and is collected in a separate cistern. This dark liquid has an exceedingly strong and disagreeable odor, and the only use of it at first was that of making coal tar. A nearly similar

tarry oil had previously been discovered in ancient times, flowing naturally out of crevices of rocks on the surface of the earth like springs of water. This peculiar tarry oil received the name of "petroleum," from the original Greek words signifying "rock oil," as being descriptive of the source from whence this extraordinary liquid was first obtained.

The natural petroleum so nearly resembles the artificial tarry oil obtained by the distillation of bituminous coal, as above described, that the same name will be applied to designate both of these products, as being alike the results of the distillation of the same material. The question is often asked, Whence is this petroleum produced?

The region of our country where the oil-springs are found gushing forth on the surface of the earth is near the frontier line dividing the anthracite coal-fields of the seaboard of the United States and the bituminous coal-fields of the great valley of the Mississippi. In this intermediate region are vast beds of bituminous coal, originally composed of the woody fibres of peat and other vegetable bodies, organized by the action of sunshine on the surface of the earth, and then covered over securely from accidental combustion. The coal is, however, exposed to a heat in the depths of the earth, which is increased regularly 1° from 50 to 70 feet of descent, the temperature at 200 feet depth having been found to be 85° in an English coal mine. The decomposition of the coal at great depths is constantly going on, and the coal gas is often heard in the galleries of coal mines rushing in hissing streams through crevices, and forming the explosive "fire-damp," which renders the safety-lamp of Sir Humphrey Davy a blessing for the preservation of the miners.

One of the deserted coal mines near Newcastle, having a 4-inch pipe connected with its chambers, has continued to distil sufficient coal gas to form a jet of flame from its open aperture on the surface of the ground "nearly sufficient to light a small town," as a recent writer has stated. From the end of a similar pipe, inserted in a drill-hole in the rocky strata on the banks of the Kanawha river, in Western Virginia, perforated to the depth of about 1,000 feet to obtain salt water, sufficient coal gas to light a city has continued for several years to rush forth, commingled with the salt water. The gas is used as fuel to boil the salt water for the production of salt. In a furnace beneath a salt pan, 100 feet long and five feet in width, the writer beheld the flame of burning coal gas, sweeping throughout in one continuous sheet, waving and flashing in wreaths of resplendent brilliancy, whilst at the same time a steam-engine was operated briskly by the same natural flow from the earth into an adjacent furnace beneath a steam-boiler. Sufficient coal gas was here discharged to evaporate the brine for making about 400 bushels of salt per day. Happening to arrive at a spot where another similar drill-hole had just been completed, an equal volume of coal gas and salt water appeared jetting upwards from the drill-hole in the rock thirty or forty feet into the air, with loud belching sounds resembling the asthmatic pantings of a powerful locomotive engine. The coal gas, here naturally elaborated, was perfectly pure and free from the disagreeable

skunky odor which characterizes the coal gas artificially elaborated in city gas-works.

The petroleum being separable by distillation from the coal at a more moderate temperature than coal gas, there is reason to believe from analogy that the same process of elaboration of petroleum goes on naturally beneath the earth as is artificially accomplished on its surface. The fact of the increased heat of the interior of the earth, in the vicinity of both the gas-springs and oil-springs in the valleys of the Alleghany mountains, is manifested in the numerous "hot springs" which gush forth unceasingly between the adjacent mountains in Western Virginia, together with numerous "sulphur springs." Indeed, this distillation of the carburetted hydrogen gas and oil from the bituminous coal, under intense pressure at great depths in the earth, constitutes a natural process of coking, whereby the flaming bituminous coal becomes gradually converted into anthracite or flameless coal.

The constantly decreasing supply of whale oil, and correspondingly increasing price of it, has recently stimulated industrial enterprise to seek out other sources of supply of this necessary article. The long-neglected oil-springs freely offered in tiny streams naturally flowing from the earth, have at last attracted attention. Impatient, however, of the stinted supply thus freely offered without labor, even some of the same resolute men who have pursued the whales among the icebergs of the polar seas and to the remotest waters of the globe, have laid down their harpoons and taken up steel drills to tap the very fountains of coal oil, in the hidden depths of the earth, in the western valleys of Pennsylvania.

The results of some of the attempts to obtain a more abundant supply of coal oil, or petroleum, have proved so successful as to appear marvellous and incredible. From one of these recent drill-holes, termed "oil wells," the petroleum gushed up with such violent force as to discharge the stream high in the air, and the flow continued so abundant that it reached the furnace of the steam-engine used for working the drill-rods. Becoming thus kindled, a vast flame lighted up the surrounding country at night. Before the conflagration could be extinguished many hundreds of barrels of petroleum flowed in a blazing flood into the adjacent rivers. In another instance, the reservoirs of petroleum being tapped by the drills earlier than anticipated and before a supply of empty casks was provided, the gushing stream was turned into a ravine and there collected by a dam to preserve it for use. Over considerable extents of valleys an abundance of petroleum has been thus obtained from reservoirs, in which it has been gradually accumulating from the natural process of distillation of bituminous coals in the depths of the earth. The ample supply of petroleum available from these sources has quite recently reduced the price of it to about fifty cents per barrel, and has nearly superseded recourse to the artificial distillation of bituminous coal. This unexpected gift to the children of men may well excite their wonder and their admiration of the provident care in anticipating human wants thus manifested by a bountiful Creator.

Both the artificial and natural petroleum in the crude state of a tarry oil are found unfit to be burnt in lamps. After numerous attempts to refine the crude petroleum by a second process of distillation, three remarkably different products were separately obtained. Each one of these three substances having a different evaporative or boiling point, like water and alcohol, they are readily separable during one continued process of distillation, by gradually increasing the heat beneath the still.

The first product that comes over from the condenser is the volatile spirits resembling ether and alcohol, called naphtha, benzole, benzine, &c., which boil at a lower temperature than alcohol, (about 150° to 160° Fahrenheit's scale.) Naphtha evaporates as rapidly as ether, producing similar lethean effects on breathing the vapor, and even exceeds ether and alcohol in inflammability.

It appears to be the common practice of the distillers of petroleum, or coal tar, to keep the heat beneath the stills very low until this naphtha has time to become evaporated at its boiling point of 160°, and to flow from the condenser in a crystalline stream into a cistern arranged to receive it. When, by the test of a hydrometer, its specific gravity is found to become increased to a certain degree by containing some of the heavier coal oil, the stream from the condenser is diverted into another cistern designed for receiving the second product of the distillation, being a heavier coal oil, commonly known as "kerosene."

The exact point where the naphtha becomes exhausted and the kerosene begins to flow is a nice question to be decided upon by the distiller. The extreme inflammability of the naphtha renders it unsafe for burning in lamps; and it cannot be advantageously reduced to vapor to be mixed with coal gas, because it does not form a permanent gas; for the vapor, like that of alcohol, becomes condensed to a liquid whenever it is cooled, as occurs on its passage through cold iron gas-pipes under ground. The only available use of naphtha is for dissolving India-rubber, and for mixing with painters' oil as a substitute for spirits of turpentine. For these reasons naphtha is nearly worthless for sale in the market; and as it constitutes ten or fifteen per cent. of the petroleum used for distillation, there is a strong temptation to the distillers to divert the current of naphtha into the kerosene oil-cistern to gratify the cupidity of purchasers by thus affording the oil at a low price. Thus both sellers and buyers are alike tempted to disregard the danger resulting from mixing the naphtha with the kerosene oil.

To gratify purchasers of coal oil by an extraordinary low price, it has been stated that dealers have contracted for the waste naphtha and residuary heavy coal oil or tar for preparing a mixture of about the same specific gravity as kerosene oil, and resembling it in appearance. The hydrometer is not, therefore, available for detecting this spurious article, and there remains no other mode of ascertaining its dangerous character than by actually testing its inflammability experimentally by the degree of heat indicated by a thermometer, at which it will become kindled by the application of a lighted match,

and begin to exhibit a lambent flame flickering over its surface, as over that of blazing alcohol. If the sample of oil contains much naphtha, it will be found capable of emitting sufficient gaseous vapor to take fire at the ordinary temperature of the air on plunging a burning match in a cup of the oil. Other samples will require to be heated to 90°, and even to 160°, before they can be similarly kindled. There is all this difference in the inflammability of the article sold in the market for coal oil. Judging of all the qualities of coal oils by some few cases of the explosive inflammability of the lowest grade in the market, they have all been subjected alike to doubts and suspicions. As the coal oils offered for sale by establishments of known respectability are really most valuable and economical substitutes for whale oil for purposes of illumination, it is unwise, as well as unprofitable, to embrace them all in one sweeping clause of condemnation without experimental examinations to determine the facts in relation to this novel subject of inquiry.

The presence of naphtha in kerosene oil essentially contributes to the brilliancy of the light for illumination, whilst at the same time it improves the combustibility of the oil by a less tendency to emit smoke. It is, therefore, for the interest of the consumer of coal oil to retain as much of this light volatile spirits as can be safely used; for it really seems like throwing away bread to reject so valuable an element of human comfort and enjoyment available as a source of light and warmth. The present waste of this material, which is now suffered to take place from fear of its wonderful combustibility, will probably be obviated ere long by new artificial chemical combinations, as ether has been reduced to alcohol and wood sawdust to a kind of sugar, so that its violent explosive tendency may be thus subdued to a more safe and manageable condition for general use in lamps.

It has, therefore, now become an exceedingly important and interesting question for insurers as well as for the insured, having property exposed to risks of fire from burning kerosene oil in lamps, to investigate carefully and judiciously the real extent of the danger and hazards resulting from this use of it for illumination, so as not needlessly to restrict the general enjoyment of this economical and valuable substitute for whale oil, and even coal gas. This investigation has become the more important as the source of supply of coal oil appears to be limited only by the supply of the vast beds of bituminous coal stored up in reserve in the depths of the earth for future generations of mankind.

To ascertain the comparative qualities of the kerosene oil made in different parts of this country, samples were procured and tested by the simple process of pouring some of each kind of oil into a cup by itself, and by placing them all afloat together in a basin of water heated by a spirit lamp, and with a thermometer immersed in the water to indicate the temperature while gradually rising from 60° to 212°. During the progress of the increase of temperature, blazing matches were passed over the surface of the oil in each cup successively at short intervals of time, until the increased heat caused sufficient gaseous vapors to arise from each to take fire; which they all

finally did, at degrees of temperature varying from 80° to 162°, exhibiting faint flames quivering over the surface of the oil, precisely like those hovering over the surface of spirits of wine or alcohol when similarly kindled. The flames were quite as readily extinguished by a blast of the breath, and not the least symptom of any explosive character became manifest when each one took fire. Until the evaporative point of each sample of oil was produced by the increase of heat applied, and until lambent flames were kindled, burning matches were extinguished when plunged into the coal oil, as effectually as if they had been similarly plunged into water. The average heat at which all the samples emitted sufficient vapor to admit of being kindled was about 125° of Fahrenheit's scale.

After ascertaining the temperature requisite to kindle the several samples of coal oil, it next becomes an interesting subject of investigation to ascertain the heat to which coal oil is ordinarily elevated whilst burning in lamps. The results of actual experiments showed that in glass lamps the temperature is increased about 6°, and in metallic lamps but 10° or 12°, above that of the apartment; which, being 67°, produced a heat in the oil of about 71° to 79°, leaving a considerable range of temperature below the average of 125°, above stated.

Finding by actual observation that only the gaseous vapors arising from the heated oil exhibit the phenomenon of flame whilst ascending, and combining chemically with the oxygen of the air, it became manifest that no explosive action could be anticipated to take place from any kind of oil or inflammable spirits, unless these gaseous vapors were first evolved by a previous increase of temperature, and then brought into contact with the atmospheric air before applying a match thereto. There being no room left for either the gaseous vapor of the oil or for atmospheric air to combine therewith, in the chamber of any lamp entirely filled with oil, every attempt to produce explosive action with a full lamp, at all temperatures up to the boiling point of water, utterly failed when lighted matches were applied to the open orifice of the lamp. The only result produced by increasing the heat of the coal oil was an increase of the evaporation of the gas, and a higher jet of flame steadily rising, as from the jet of a gas-burner. So long as lamps are kept full of oil, or even of explosive camphene and "burning fluid," there can be no explosive action whatever. For this special reason it may be adopted as a safe rule to cause all lamps containing highly imflammable liquids to be kept as full as practicable by being daily replenished.

As nearly all the published accounts of the explosions of camphene lamps, and of the consequent dangerous and frequently fatal consequences that have ensued, represent the occurrences to take place during the process of filling them whilst empty, the chamber of the lamp or of the feeder being then occupied by gaseous vapor commingled with atmospheric air, an experiment was made with a glass factory lamp under similar circumstances, as being favorable for exhibiting the most violent explosive action producible by means of coal oil. Accordingly a lighted match was plunged into the orifice of

a burning lamp containing a little kerosene oil of the ordinary temperature, without producing any perceptible explosive effect. In this state it was also filled safely. To test the effect of increasing the heat of the coal oil higher than 80°, the lamp, whilst still burning, was placed in a basin of water, the temperature of which was gradually raised to the boiling point. During the progressive increase of temperature burning matches were continally inserted into the orifice of the lamp without perceptible effect in kindling vapor, until the heat became increased to nearly the temperature at which the oil had been found susceptible of being kindled in an open cup. The only mode of producing a slight explosive puff on inserting a burning match was by violently shaking the lamp to increase the evaporation and mix the gaseous vapor more thoroughly with the atmospheric air. But when the temperature of the coal oil became further increased to about 160°, the rising gaseous vapor entirely filled the chamber of the lamp and expelled the atmospheric air so completely as to cause lighted matches to be extinguished within the chamber, whilst the ascending gas continued to blaze with a slight flame above the open orifice. Indeed, with the sample of oil which did not emit sufficient gaseous vapor to become kindled at a temperature below 125°, it required dexterous manipulation to so apportion the gaseous vapor and the atmospheric air as to exhibit the faintest action of an explosive character.

Continuing the experiment with the kerosene at a still higher temperature than 212°, by pouring it into an iron ladle over a hot fire, the gaseous vapor arose therefrom still more rapidly, until it became a visible smoke ascending regularly in a column from the ladle even whilst heated red-hot, without becoming kindled into flame until a lighted taper was brought into contact with it; then the gaseous vapors became resolved into a bright column of steady flame without any evidence of an explosive tendency.

Whale oil, tallow, rosin, and pine sawdust were similarly exposed in the same heated ladle with precisely similar results, showing that the kerosene was no more explosive than either of these substances, and that they all alike became decomposed at a high temperature into their constituent elements of carbon and hydrogen, or carburetted hydrogen gas. One measure of this inflammable gas is found to form a new chemical combination with about three measures of atmospheric air when kindled, and to exhibit the phenomenon of an elongated flame whilst the combination is taking place between the ascending particles of the surface of the gas and the particles of air in immediate contact therewith. This result is manifested in the form of the flame of a lamp or gas-burner. But if one measure of carburetted hydrogen be thoroughly mixed with four or five of atmospheric air, so that the particles be all brought into intimate contact with each other, then the combination takes place simultaneously throughout, producing the sudden and violent expansive action denominated an "explosion." In order, therefore, to produce an explosion of a lamp or of any other vessel, it is only necessary to mix the gases of de-

composed oil, coal, or wood with this combining portion of atmospheric air, and then to apply a lighted match to the mixture.

Dangerous explosions are thus often produced in common stoves on suddenly decomposing the wood, shavings, or paper used therein for kindling, by throwing red hot coals upon them. The carburetted hydrogen, rising in the form of a dense smoke, becomes commingled with the atmospheric air occupying the chamber of the stove, and on being kindled the whole simultaneously flashes into flame. In "air-tight stoves" these explosions have often proved destructively violent to persons and property.

Thus there may ensue dangerous explosions even in lighting a fire in a stove; and most fearful explosions have often taken place in apartments of dwelling houses when about one-fifth part of the space therein becomes occupied by coal gas escaping from leakages of gas-pipes. The difference in the extent of the violence in such cases is simply due to the greatly increased quantity of the explosive gas accumulated in large rooms, as compared with the diminutive chambers of common lamps. The extent of the danger to both life and property is thus correspondingly magnified. Even adjacent buildings have thus been damaged and many lives destroyed by such explosions of coal gas.

There is, therefore, the same danger of explosions in the use of coal gas in houses as in the use of coal oil in lamps where ordinary care and caution are not exercised. Were about five parts of atmospheric air mixed in a city gas-works with one part of the coal gas, and thus distributed for use, the jet of gas kindled at a burner would communicate the flame to the interior of all the main pipes and gas-holders, and a general simultaneous explosion of all would ensue. The same parallel has been applied to excluding atmospheric air from the chambers of kerosene oil lamps by keeping them filled with oil.

To compare practically the violence of the explosion of common coal gas with that of the inflammable kerosene coal gas and of naphtha, a small tin vessel of the capacity of a factory lamp was made for the experiments; the results of which showed that the coal gas was the most readily explosible, the extent of the explosion, however, being only a slight puff from the orifice of the tin vessel.

The slightness of all the explosions in the experiments that have been recapitulated is ascribable to the small proportion of one-fifth pure oxygen gas contained in the atmospheric air, the remaining four-fifths being composed of incombustible nitrogen. Were pure oxygen substituted for the diluted atmospheric air, the explosions would have been dangerously violent. Indeed, were the atmosphere composed of pure oxygen, the iron grate bars of a furnace would burn more brilliantly than the most combustible fuel placed thereon, and explosions and conflagrations would continually occur with irresistible violence. It is owing to the presence of the pure oxygen gas evolved by heating saltpetre, and commingled with the carburetted hydrogen gas evolved from the ignited pine floors and partitions of warehouses, that the most frightful explosions have occurred, which have often blown up great warehouses and destroyed many lives. This fact

22

appears to have been lost sight of in the numerous discussions of the questions of "the explosibility of saltpetre," which have been published, and in the experiments that have been made to solve practically this unsettled question. These experiments have shown that where fragments of charcoal not finely pulverized, such as are produced from burning wood, and from cloth commonly used for bagging, are thrown upon heated saltpetre, a prolonged vivid combustion has ensued, termed *deflagration*, in contradistinction to *explosion*, the contact of the two substances being confined to the surfaces of the solid masses. To produce explosive action with saltpetre and charcoal when ignited, it has therefore been found necessary to pulverize both substances very finely and then to commingle them, atom to atom, artificially, with the utmost care, as is practically accomplished in the manufacture of gunpowder. When thus prepared, the saltpetre sets free sufficient pure oxygen to be chemically combined, atom to atom, with the charcoal or carbon in the confined chamber of a cannon, independently of a supply of the oxygen gas from the external atmospheric air. In this way only is an explosion directly producible by saltpetre. But indirectly, as occurs in a burning warehouse, a still more violent explosion than that of gunpowder is producible by simply mixing together the gaseous products of saltpetre and burning wood, as the following experiment, made in the laboratory of Brown University, with the co-operation of Professor Hill, will forcibly demonstrate.

Some saltpetre was put into a retort, and subjected to the heat of a furnace, to represent the action of the intense heat of a burning warehouse on saltpetre stowed therein. The gas evolved from the saltpetre was collected in a glass receiver. Some fine sawdust was put into another retort, similarly heated in a furnace, and the rising carburetted hydrogen gas was collected in another receiver inverted over water. The two gaseous products were commingled in the proper combining proportions, and introduced into a small tin tubular chamber, with a cover loosely fitted on its top, and a small hole pierced in its side, to which a lighted match was applied. An explosion ensued so violent and rapid that the top of the circular cover was burst off from its soldered edge before it was lifted up, and the hoop of it split open and thrown to a distance with a deafening report.

After witnessing the violent and stunning explosion thus produced by a minute quantity of the mixed gases of pine wood and saltpetre, the professor remarked that a room full of such an explosive mixture might produce the terrific effect of the explosion of a magazine of gunpowder.

The dense smoke of burning floors, constituted of carburetted hydrogen, and the pure oxygen evolved by the heat of them from the saltpetre, might ascend into some adjacent room and remain commingled there, ready to explode by the first flash of flame which might reach them there.

The explosiveness in this case manifestly originates from the chemical combinations of the oxygen gas, set free by heating the saltpetre, with the carburetted hydrogen gas, set free by the heating of the

pine wood, and not from any explosive property in the saltpetre itself. For this special reason saltpetre stored by itself, without the proximity of wooden floors beneath it, should not be considered in the class of a hazardous risk for fire insurance, or intrinsically dangerous.

As the dangerous inflammability of coal oil appeared to be ascribable to the naphtha not separated therefrom, the following experiments were made to ascertain the extent of the inflammable properties of pure naphtha.

Finding that the liquid naphtha evolved sufficient vapors at the ordinary temperature of the atmosphere to become instantaneously kindled into flashing flames, the cup containing it was immersed in a freezing mixture of snow and salt to reduce the temperature to the zero of Fahrenheit's scale. At this low temperature the naphtha appeared to blaze with equal violence. Then a quantity of snow was mixed with the liquid naphtha and thoroughly stirred, for still further reducing the temperature. Even at this extreme degree of cold the naphtha continued to flame so furiously that it was necessarily thrown from the cup, upon the ice covering the ground where the experiment was made, in the open air, whilst the thermometer indicated an atmospheric temperature of 19° below the freezing point. The naphtha still continuing to burn upon the surface of the ice, a covering of snow was thrown over it to extinguish the flame. Through this covering of white snow the bright flames still continued to shoot up, presenting to view the extraordinary spectacle of burning snow.

On repeating similar experiments on the comparative combustibility of spirits of wine or alcohol, camphene, and burning fluid, they did not emit sufficient gaseous vapors at the freezing point, or 32°, to become kindled into flame, when burning matches were plunged therein, but with a little increase of temperature they all became kindled.

The preceding experiments seem to exhibit impressively the extraordinary inflammability of naphtha, arising from the facility with which it emits gaseous vapors. Susceptible of being readily kindled into flames, even through a mantle of snow, naphtha, like ether, emits gaseous vapor, which, with surprising facility, pervades the air; and the odor of it being rather pleasant than offensive, like that of artificial coal gas, the utmost caution is requisite to prevent not only unexpected explosions; but also the almost unextinguishable violence of its conflagration, for practically the application of water does not subdue the conflagration of naphtha in quantity, and only the exclusion of atmospheric air appears to quench the fury of its flames. To prevent the escape of the gas through the porous wooden staves, it has been found necessary to coat the inside of the barrels with a solution of glue.

The insidious nature of the gaseous vapor of naphtha is therefore its most dangerous quality, for when stored in barrels in a warehouse, with the bung holes of the barrels open, sufficient vapor escapes into the air of a close apartment to produce a violent explosive action on introducing a lighted candle. In this way, notwithstanding the precautions used at the distilleries of coal oils, several of them have been

first shattered by explosions of the naphtha vapor and then burned down.

Petroleum contains a considerable percentage of naptha, and consequently partakes in a degree of its dangerous properties. There appears to be sufficient reason for classing these liquids as specially hazardous.

In making experiments with the tin vessel of the capacity of a common lamp, (before described,) a single drop of naphtha was found to yield sufficient vapor to produce as much explosive action as could be produced by the most inflammable coal oil for sale in the market, when similarly experimented with ; and after every experiment failed to exhibit the slightest explosive tendency of the best kerosene oil, a single drop mingled therewith rarely failed to yield sufficient vapor to manifest its presence by a slight explosive puff when kindled by a lighted match. The combustion in this case was confined to the minute quantity of naphtha gas, without either kindling the kerosene oil, or dangerous results.

In all the accounts of the explosions of camphene and burning-fluid lamps there appears to be no statements of any damage or injury to life or property by the mere mechanical force developed. The principal disastrous results are caused by the scattering about of highly inflammable liquids, which instantaneously spread the conflagration over surrounding combustible substances. It is sufficient to produce the most disastrous consequences, if a lamp containing any of these highly inflammable liquids produce only a sufficient gust of an explosive character to disperse the blazing contents over the dresses of adjacent persons or surrounding combustible matter. The rapid communication of the flames has in this way often proved fatal to life and destructive to buildings. For this reason the rates of premium for fire insurance have been enhanced on property jeopardized by the use of camphene and burning fluid in lamps for lighting factory buildings. As the accidental fall and breakage of camphene or burning-fluid lamps on a floor have often produced the loss of life and property by communicating fire, as above stated, an experiment was made to test the comparative results which might be anticipated from a similar accident to a burning lamp containing coal oil, which required to be heated to 125° before it emitted sufficient gaseous vapor to be kindled by a lighted match. Some coal oil of this quality was poured out of a burning lamp upon a floor and the blazing wick dropped therein. There it continued burning until the heat of it raised the temperature of the surrounding coal oil to 125°, when the blaze began gradually to spread over the surface of the oil on the floor in an enlarging circle, but no sudden flash of flame spread over the whole surface at once, as was the case when burning-fluid and camphene were similarly experimented upon.

To represent the effect of accidentally spilling the kerosene oil from a burning lamp upon a cotton dress, a piece of calico cloth was moistened with the oil, and then held up in contact with the flame of a lamp. The kerosene required a little time for its temperature to become raised to the evaporative point of 125°, before the blaze

began to spread over the surface of the calico, and it was readily extinguishable by the breath when first kindled. Although a single calico dress may of itself be deemed dangerously inflammable, yet it requires more time to become ignited whilst wet with kerosene oil, but the intensity of the flame becomes finally much greater.

When a similar experiment was repeated on cotton cloth moistened with burning fluid, camphene, and spirits of wine, the blaze spread instantaneously over the surface of the cloth with terrific violence, affording ample reason for the belief of an increased hazard in using them in lamps even for household illumination; and yet how few are the disastrous accidents which have occurred from this cause, in comparison of the vast number of cases where lamps supplied with these inflammable liquids have been harmlessly used with ordinary care.

An important incidental security, resulting from the use of kerosene in lamps, is an exemption from the crusts of coal which are found to collect on the wicks where whale oil is burnt, and which not only obscure the radiance of light, but frequently sparkle off upon adjacent combustible bodies. It is necessary often to trim the wicks of whale-oil lamps, which in manufactories is frequently done by workmen, impatient at the waning glimmer. The burning crusts of the wick, knocked off without regard to surrounding combustible matter in cotton mills, has often set them on fire and burned them. Turpentine is also used for lighting the wicks of such lamps, which increases the danger in cotton mills. For these reasons it is believed that the comparative hazard from fire by the use of whale oil in lamps in cotton mills is greater than where coal oil is similarly used, of the quality before stated.

Although pure sperm oil may be free from the preceding objection, yet, so great is the temptation of a profit of about one dollar per gallon from mixing the cheaper whale oil with sperm oil, that it has become nearly impracticable to obtain a sufficient supply of the latter, even for oiling machinery. So great, indeed, has been found the difficulty of procuring pure sperm oil in England for this purpose, that the heavier coal oil has been there successfully substituted in place of it for this special purpose.

Ample capital and skill have recently been applied to the new branch of business of the distillation of coal oils, and no deficiency of an abundant future supply will hereafter occur for purposes of illumination, or, when properly prepared, for lubrication of machinery. It appears that an entire cargo of coal oil has recently been exported to Italy. The supply of coal oil will not fail until the supply of coal in the depths of the earth becomes exhausted. How long this may continue has already become a curious subject of calculation.

The consumption of coal for purposes of navigation, and for motor power in the useful arts, is manifestly destined to go on, increasing with an increasing population to a vast extent, whilst no compensating supply is accumulating in new deposits or formations of fresh beds of coal to replenish the decreasing stock. In anticipation of the

exhaustion of the coal mines of England, the question of restricting the exportation of coal has been debated in Parliament, and a recent writer has published in the London Quarterly Review an estimate, limiting the supply to a period of about one thousand years, and then, he observes, "recourse must be had to the vastly more extensive coal fields of North America." In a sort of geological inventory of the stock of coal on hand in the possession of some of the principal nations of the earth, it appears that there are about 135,000 square miles of area of coal fields in the United States, 18,000 square miles in British North America, 12,000 in Great Britain, 3,500 in Spain, and only 1,700 in France. The possession of abundant supplies of coal and iron by races of men having the intelligence and vigor to use them effectively, constitutes, at the present day, the basis of natural greatness, as exhibited in the effects of the annual production of seventy millions of tons of coal by Great Britain for the developments of manufactures, commerce, and the physical comforts of the people.

These facts impart to the present subject of inquiry exceedingly interesting as well as instructive considerations connected with the probable future supremacy in the useful arts and national power of the people of different countries of this earth. The coal fields of this western continent have only recently begun to yield up their hidden treasures of mineral coal and petroleum. Our country is still literally "the new world." Provided with a tenfold greater supply of coal and iron than Great Britain, and with far more than all the rest of the continent of Europe besides, this physical power is destined to be developed with a paramount influence on the affairs of men in remote ages of futurity, after the present wilderness of North America shall have been made "to blossom as the rose." Inspired with glowing anticipations of the future destiny of America, resulting from the possession of vast regions of fertile land and mineral treasures hidden beneath its surface, Bishop Berkely inscribed his prophetic verse—

"Westward the course of empire takes its way."

The preceding experimental facts have been investigated for the special purpose of showing that all these bountiful provisions, stored up for the future well being of man on earth, may be safely used with due care and forethought, without which even a draught of cold water might prove a fatal beverage. The minuter details have also been added, to dispel unfounded apprehensions of danger in the use of coal oils properly distilled at establishments of known credit and respectability, and to awaken caution where there is real cause for alarm, that these gifts of a bountiful Creator may be rendered subservient to human enjoyment and happiness.

DESTRUCTIVE EFFECT OF IRON-RUST.

TRANSLATED FROM THE GERMAN JOURNAL "AUS DER NATUR," VOL. 13, PAGE 153.

It has been frequently observed that in timber of old ships where-ever iron nails or bolts have been driven the wood in their proximity is entirely altered. All around, to a distance of an inch and more, and parallel to the direction of the woody fibres, as far as the iron has entered, a part of the material is dissolved away, leaving the remainder half charred, as it were, and quite brittle, so that it may be easily broken into pieces, the fibres having entirely lost their cohesion. Thus, the wood around the nails has the appearance as if these nails were driven in when red hot. This injurious effect of the iron-rust may be considered as one of the principal causes of the want of durability of our ships.

Rust not only originates in places alternately wet with sea-water and again exposed to the air, but also where the iron is permanently submerged under water, for this also contains the elements for the production of rust, namely: carbonic acid and oxygen. Rust, as is generally known, is an oxide of iron, and as soon as it comes into contact with wood it gives off part of its oxygen and becomes reduced to protoxide. The latter takes up a new portion of oxygen and transfers it again to the wood, and by the uninterrupted repetition of this process a slow oxydation or decay of the wood is effected. Thus the protoxide of iron in this case plays a part similar to that of the nitric oxide in the manufacture of sulphuric acid, with the only difference that the transfer of oxygen in the one case is of essential benefit to arts, and in the other, decidedly injurious.

In order to demonstrate the fact that oxide of iron is reduced by the mere contact with organic substances not yet in a state of putrefaction, Kuhlmann, in Lille, has instituted different experiments, the results of which confirm the correctness of this assertion. When hydrated oxide of iron was shaken with cold solutions of several coloring matters, such as log-wood, Brazil-wood, cochineal, curcuma, mahogany, but not indigo and litmus, they became decolorized, lac dyes having been formed. In these the iron was found in the state of protoxide, and consequently the oxide of iron had lost a portion of its oxygen by the action of the coloring matter. Solutions of cane-sugar, grape-sugar, and gum were boiled with hydrate of oxide of iron. Of these the grape-sugar acted powerfully, reducing the oxide even when cold; this action was less with cane-sugar, and least with gum. When oil of bitter almonds was heated with dry hydrate of oxide of iron, to a temperature of 100°,* it was altered into benzoic acid, which enters into combination with the protoxide of iron.

*Probably Celcius scale.—Translator.

Similar cases, where oxide of iron acts destructively upon organic substances, frequently occur in everyday life. If, for example, linen or cotton cloth in which there are inkstains is repeatedly washed with lye, the texture of the stained spots becomes tender, or even falls out. Like injury is done by the *lustre(?)* colors, (rust-yellow and black-brown,) which are fastened upon the cloth by first soaking it in a solution of sulphate of protoxide of iron or protoxide of manganese, passing it when dry through lye of caustic potash, and then exposing it to the air, by which the protoxide is changed into oxide. By this process the cloth loses its durability, and the common saying is, that it is burnt in dyeing. But this diminution of the strength of the cloth is not an exception, produced by a mistake in the application of the method; it is the normal result. As an explanation of this process, it was supposed that any oxydizing substance may dispose any other with which it is in contact to combine with oxygen, even when otherwise not inclined to such combination. According to Kuhlmann, however, the oxide of iron directly transfers the oxygen to the cloth, and ceases its action only when the destruction is complete.

Several phenomena, observed in bleaching, can be explained in the same manner. If, for instance, the inner surface of the soaking tubs made of sheet-iron and used in dyeing or bleaching becomes bare by the removal of the calcareous sediment, and if the cloth comes into immediate contact with the iron, then those places to which the air has access are covered with rust, and the strength of the cloth is inevitably impaired. In bleaching the ordinary goods, which are made from refuse cotton, all the parts of the material which in the carding process have become soiled with iron are exposed to this oxydizing action, and this often to such a degree that within four or five days holes are eaten through the texture.

Kuhlmann thinks that this energetic action of the oxide of iron is an additional condition for the spontaneous combustion of refuse cotton and wool, which so often occurs. It is true the ready reception of oxygen by the oil, with which such refuse is always more or less saturated, favors the spontaneous ignition, yet the oxide of iron may frequently afford an additional cause and favor the commencement of the combustion.

The objection to the use of iron nails, which we mentioned, is of sufficient importance to induce us to look for a remedy. In order to avoid the destructive action of rust upon wood-work, copper nails must be used instead of iron ones, wherever the first cost is not an essential object. They are, however, too expensive for general use, and therefore iron nails coated with tin or zinc should be substituted.

How important inferences for agriculture may be drawn from these observations, we shall see in another article.

ARCHÆOLOGY.*

THE LACUSTRIAN CITIES OF SWITZERLAND:

DISCOVERY OF A LOST POPULATION.

LACUSTRIAN HABITATIONS OF ANCIENT AND MODERN TIMES, BY M. FREDERIC TROYON: LAUSANNE, 1860.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION FROM THE REVUE DES DEUX MONDES: PARIS, FEBRUARY, 1862.

Our historians have often regretted that they were reduced to hypotheses respecting the ancient inhabitants of Gaul. Nineteen centuries have already elapsed since the expeditions of Cæsar, and it is only to-day that a ray of light falls upon the tribes once scattered over the territory which is now our country. The Roman conqueror who boasts of having exterminated a million of our ancestors on the field of battle is also the first writer who adequately describes the manners, the religion, the political constitution of the different tribes comprised under the name of Gauls; but to what origin are we to refer all those tribes—Belgians, Celts, Iberians? History, in the received sense, is almost silent in this respect, and it is to other sciences that we must have recourse if we would trace through the obscurity of centuries the migrations of our fathers and the shifting boundaries of their possessions. Inductions derived from language and from comparative anatomy assist the learned in these difficult researches, but do not suffice to give the character of evidence to the conclusions generally adopted. Conjectures are not yet transformed into indubitable facts.

If the ancient names of places disguised by long usage are of great importance for the reconstruction of the history of the Gauls, the remains of the monuments they raised are of much higher value. A few ruins studied with sagacity teach us more respecting the manners, the domestic life, and the true history of lost populations than whole dictionaries of recovered words. Even nations which have left us

* The article entitled "General Views on Archæology," by A. Morlot, of Switzerland, of which a translation was given in the last Smithsonian Report, has tended so much to awaken a new interest in the study of the remains of the ancient inhabitants of this continent that we have been induced to insert a number of other articles on the same subject in the present report.—Secretary S. I.

their chronology and the story of their deeds seem to live anew when we make the discovery of their habitations, of the thousand objects with which their daily life was familiar, of the very articles on which they subsisted. Has not that history of Assyria, which seemed so remote, been reanimated by means of the bas-reliefs and winged bulls of Nimroud, and is not an image of Roman society recalled through the excavations which have restored Pompeii? Unhappily, traces of the successive populations which have inhabited Gaul are rarely to be met with in places where we might especially have hoped to find them. It is not on the rich and fertile plains, nor on the banks of the great rivers. where the potent communities of Gaul were heretofore established, that we must seek the remains of the habitations of our fathers. Their destroyed cities have been succeeded by so many others richer and more populous, the soil has been so often turned over and over, ruins have been so repeatedly mingled with older ruins, that all remains of the ancient occupation have mouldered into dust; time and man have labored in concert to efface every vestige. In order to surprise the secret of those elder populations we must explore the barren tracts where habitations have been always thinly scattered, above all, the forest districts which invited the hunter, but offered no inducements to agricultural colonists when conquest had once deprived them of their primitive inhabitants. While the more historic regions of our country scarcely present any remains older than the Gallo-Roman epoch, the heaths of Brittany and the wooded vales of Poitou have preserved their *dolmens* and their ranges of *menhirs;* the sterile downs of central France exhibit their *fosses a loups*, *marges*, or *mardelles*, which formed the under-ground story of the Gallic houses; and when we penetrate into the deep pine woods of the Landes we are surprised at the sight of the vast *clotes* hollowed in the earth and left untenanted since the day when some invasion of Celts or Basques drove away the occupants. Solitude has protected these retreats of a people which no longer exists.

The interior of the soil has preserved, in great number and still better than the forests and the wolds, evidences of the sojourn of our ancestors. Many natural and artificial caverns are rich in Gallic antiquities. Beds of alluvium, lightly deposited by flowing waters, embosom remains of human industry, and form, as it were, an immense museum, which modern explorations have as yet scarcely disturbed. Even lakes and rivers hide under their crystal or turbid expanse genuine archælogical treasures consisting of all the objects abandoned by the riparian tribes. Certain researches made in Ireland had already given an idea of what might be expected from the scientific exploration of lakes, when accident threw the savans of Switzerland upon the track of the most important discoveries. Thanks to them, and especially to M. Troyon, their principal interpreter, the field of our knowledge has been singularly enlarged: a lost population has been discovered in the lacustrian basins of the Alps and the Jura. We have here no fact of simply national interest; it is the best established indication which science possesses for the ancient history of western Europe. Although the localities of these discoveries oblige the

author of the *Habitations Lacustres* to confine himself almost exclusively within the actual limits of Switzerland, it is not the less certain that the ancient civilization with which he is engaged spread itself extensively over both Gaul and Italy.

I.

During the winter of 1853–'54 a remarkable depression was observed in the level of the Lake of Zurich : the retreat of the waters laid bare a wide surface, of which the inhabitants of the shores took advantage to construct dykes far in advance of the ancient water line, and thus acquired extensive tracts which had been hitherto submerged. Near the hamlet of Obermeilen the laborers occupied in the work of embankment discovered, under a bed of mud of half a demimetre in depth, some piles, bits of charcoal, stones blackened by fire, bones and various utensils which indicated the existence of an ancient village. Having been informed of this interesting discovery, M. Ferdinand Keller, of Zurich, hastened to investigate the relics just discovered, and soon after announced to the scientific world the result of his researches. This formed the starting-point of incessant explorations. MM. Uhlmann, Jahn, Schwab, Troyon, Forel, Rey, Desor, and many others have from that time been engaged in having the shoals of the Swiss lakes dredged. For the purpose of discovering traces of ancient habitations, they sounded the alluvial deposits formed on the lacustrian strands and in the deltas of rivers, and with the same view they have visited the lakes of Italy, those of the French Jura and of Savoy; hence their collection of historical materials is constantly increasing. Within the limits of their own country alone they have discovered under the surface of the waters the remains of a hundred and fifty villages, and no season passes without their announcing new ones. Already the larger cities of Switzerland and many learned individuals offer to the inspection of the curious archæological museums comprising thousands of ancient relics. From the aquatic village of Concise alone, which is situated in the lake of Neuchatel, about twenty-five thousand objects have been obtained, and perhaps even a still more abundant crop may be gathered, since the historic layer spread along the bottom of the lake is of the thickness of a metre.

It is easy to conceive the principal reason which determined the ancient tribes of Helvetia to erect their constructions on the shallows of lakes. Before the Roman epoch the valleys of the Alps were covered with immense forests, through which roamed the bear, the wolf, the boar, the urus, and other formidable animals, while man, since war must from time to time have raged between the scattered tribes, was still more to be dreaded than the wild beasts. The first care of each group of families, therefore, was to secure its safety against an unforeseen attack by establishing itself in some place defended by natural obstacles. In mountain regions, some would select high and precipitous acclivities; others take refuge in caverns on the sides of perpendicular rocks and fortify the entrance to their subterranean

abode. In watered plains, the peninsula formed by the confluence of two rivers or by the windings of the stream offered inducements for a residence, while those who inhabited countries strewn with lakes, like Switzerland and Savoy, abandoned the dry land and built their huts in the midst of the waters, at some distance from the shore. Here they found the surest means of guarding against sudden attack, with the advantage of being able to transport themselves at pleasure in their canoes to every point of the coast, their rude structures serving at the same time as stations for fishing. Perhaps, also, in choosing the surface of the lakes as a sojourn, they obeyed that irresistible attraction which allures every infant colony towards the water. At all the epochs of history, and in all parts of the world, the requirements of defence and the facilities of fishing, joined with the natural charm of beauty in sheets of water, have determined many tribes of men to build their habitations, whether of boughs or of reeds, above the surface of the waves. There are Assyrian bas-reliefs, which show us men inhabiting artificial isles formed of interlaced reeds, and, according to Hippocrates, the colonists of the Phasis, whom the fishermen of the Volga imitate to this day, raised their huts of rushes in the midst of the river. A well-known passage of Herodotus informs us that the Pæonians of Thrace likewise built their villages on piles driven into the soil of the shallows of Lake Prasias. In our own day the Malays and Chinese established at Bankok and on the coasts of Borneo construct their houses on posts planted in the water at some distance from the shore. Again, when the Spaniards discovered the lagoon of Maracaibo they were surprised at seeing a city on piles, a diminutive Venice of wood, to which one of the republics of Colombia owes its present name of Venezuela.*

It would be easy, even if all the structures of this kind existing in different parts of the world furnished no medium of comparison, to rebuild in thought, by help of the numerous relics found at the bottom of lakes, the lacustrian cottages of ancient Helvetia. A mere glance of the eye through the transparent water enables us to perceive piles in parallel rows, or planted, it may be, without order. The charred beams which are seen between the posts recall the platform once solidly constructed at a height of some feet above the waves. The interlaced boughs, the fragments of clay hardened by fire, evidently belonged to circular walls, and the conic roofs are represented by some layers or beds of reeds, straw and bark. The stones of the fire-place have fallen just below the place which they formerly occupied. The vessels of clay, the heaps of leaves and of moss which served as beds for repose, the arms, the trophies of the chase, the large stag horns and skulls of wild bulls which adorned the walls, all these different objects, mingled together in the mud, are nothing else but the ancient furniture of the habitations. By the side of the

* The *crannoges* of Ireland, some of which were still inhabited so late as 1610, differed from the lacustrian settlements of Switzerland: they were real wooden fortresses built on artificial islets.

piles we can still distinguish remains of the hollowed trunks of trees which served for canoes, and a range of posts indicates the pristine existence of a bridge which led from the threshold of the lacustrian dwelling to the neighboring shore. Not only are we enabled to determine from the number of piles what were the dimensions of the largest aquatic cities, composed generally of two or three hundred cabins; we can even measure in some cases the diameter of the huts constructed so many ages ago. The fragments of the coat of clay which lined them on the inside show on their convex face the marks of the interlaced boughs of the wall, while their concave side is rounded into the arc of a circle; by calculating the radius of this arc we find that the size of the habitations varied from three to five metres, (10 to 16 or 17 feet,) dimensions quite sufficient for a family which seeks in its dwelling a simple shelter.

Athwart an interval of thirty or forty centuries we can conceive how picturesque an effect must have been produced by this agglomeration of small huts closely compacted together in the midst of the waters. The shore was uninhabited; a few domestic animals alone fed in the grassy clearings; great trees spread their masses of verdure over all the slopes; a deep silence brooded in the forest. Upon the waters, on the contrary, all was movement and clamor; the smoke curled above the roofs; the populace bustled upon the platforms; the canoes passed and repassed from one group of dwellings to another, and from the village to the shore; in the distance floated the boats which served for fishing or for war. The water seemed then the real domain of man.

From the first of their discoveries the Swiss archæologists decided that the lacustrian habitations did not all date from one and the same epoch. The study of the objects found at the bottom of the lakes has led them to divide the first cycle of our history into three ages: the age of stone, of bronze and of iron. The scientific inquirers of Scandinavia had already established these three successive periods in reference to their own country; but these ages were not cotemporaneous in the two countries. Civilization was then propagated with the utmost slowness, and centuries passed away before each progression in human industry could penetrate from the south of Europe into the cold regions of the north. The habits of the people were only changed by force of prolonged wars or through distant migrations.

It is in German Switzerland chiefly that the traces of settlements belonging to the age of stone have been recognized. Western Switzerland likewise possessed important lacustrian cities, among others that of Concise, near the southern extremity of Lake Neuchatel, but the Lakes of Zurich and of Constance appear to have been the most active centres of population. It was then that the pile-work of Obermeilen was erected, the discovery of which was the starting point of all that has been since effected. Thanks to the relics obtained at that point, and on the shores of the Lakes of Constance, of Pfaeffikon, of Sempach, of Wauwyl, of Mooseedorf, we can at this day sketch in broad lines the manner of life of the lacustrian populations, and give some general but certain indications with regard to their history.

One of the most surprising considerations suggested by the view of the remains of these primitive constructions is the vast amount of labor accomplished by men who had at their disposal no other implements than flint-stones and the brands of their fires. There was an abundance of trees, tall and straight, growing in the forest, but to fell and trim them it was necessary to employ alternately the sharpened stone and the flame, and afterwards, by the same means, the end of the log was to be reduced to a point, that it might penetrate easily into the soil to a depth of several feet. The hewing of the trunks of trees, which were to serve for floors and esplanades, and which were cleft with wedges of stone, in order to form a sort of planks, demanded still more labor than the preparation of the piles. What time and pains must have been expended when it was requisite to level a trunk of oak from 10 to 15 metres long, and to shape it into a canoe! Some villages, of which we still see the remains, were reared on more than forty thousand piles. It was the work, no doubt, of several successive generations, but for each of these an incessant labor is not the less implied. In addition, the *lacustrians* (for it is by this name that these primitive populations are now designated) dug lines of trenches on the firm lands to protect their domestic animals from wild beasts; they reared *tumuli* and other religious monuments on the heights; at one and the same time they carried on war, the fishery, and the chase; they likewise cultivated the ground, and for so many different occupations had no instruments at their command but those of stone and of bone. The fabrication and the repairing of these instruments must have required inexhaustible patience, for the stone must be cut with stone, and it is with difficulty that we can conceive how these unwearied artisans succeeded in giving a finish to points and blades of silex. They attacked the hardest substances, and worked even in rock-crystal.

"The hatchet," says M. Troyon, "played the greatest part in the primitive industry." This implement is found by hundreds on the sites of the ancient villages. Not only was it the weapon of hunting and of war; it served also for the most various domestic uses, and probably never quitted the hand or the belt of its owner. The blade of the Swiss hatchet, most frequently hewn from a block of serpentine, is much smaller than that of the hatchets used in Scandinavia during the age of stone, and is of an average measure only of from 4 to 6 centimetres. The mode in which the handle was attached to these sharpened stones varied considerably: some were adjusted, by means of ligatures or mortises, at the end of curved sticks; others were made fast to handles of deer-horn. It was as the national weapon that it most exercised the imagination of the workman and artist. Each warrior modified it according to his personal taste, and perhaps ornamented it with feathers and fringes, like the Indian redskin. Other arms, of less importance than the hatchet, were the arrows of flint or of bone fixed in the end of long reeds; they resemble those discovered in France, in England, and on the banks of the Missisippi, but in general they are not so long as those of Scandinavia. It is very probable that the sling was in use. Rough stones also served

for projectiles, as is shown by the pebbles with sharp corners lying heaped together in the mud at the side of the piles; too small to be used in the fabrication of implements, they could have been intended for no other purpose but that of defence. Not content with these arms, the lacustrians, skilled already in the art of war, had contrived incendiary balls and bullets formed of charcoal kneaded with clay. These instruments of destruction, which were generally pierced with a hole, that they might be better thrown, could only have served for attack; they were ignited, and then tossed on the roofs of the hostile huts. If some projection detained them, they burned insidiously on the dried thatch, the fire spread by degrees, and soon the top of the structure was wrapt in flames. It was thus that the Nervii fired the camp of Cæsar. From the first days of his history man has employed his ingenuity in burning and destroying.

Among the instruments of labor manufactured by the lacustrian people of the age of stone may be cited blades of silex, edged or toothed, which served as knives and saws, hammers, anvils, awls of bone or of deer's horn, paring-knives, and needles, which were destined, no doubt, for cutting or sewing leather or skins. The fragments of pottery which occur are formed of a coarse clay, the paste of which is usually intermingled with small grains of quartz. These vessels betray the infancy of the art, and very seldom present traces of ornamentation. Some, of quite a fine paste, have a smooth surface, and are colored black by means of graphite. At Wangen, on the borders of the Lake of Constance, at Robenhausen, in the Lake of Pfaeffikon, mats of hemp and of flax, and even real cloth, have been discovered, as well as small baskets in all respects like those of ancient Egyptian tombs. The lacustrians manufactured likewise cords and cables from textile fibres and the bark of various trees. Vain, like all savages, they bestowed great pains on their corporeal beauty, and sought to enhance it by numerous artifices; they tucked up their hair with pins of bone, decorated their fingers with rings and their wrists with heavy bracelets, and loaded their shoulders with collars formed of balls of deer's horn, mingled with bits of stone; on their breasts they wore the teeth of bears, doubtless to endue them with the force of the wild beast and preserve them from mischances. The large disks of stone found at the bottom of their lakes served as quoits to amuse them after the arduous labor of the day. The pierced nuts now scattered in the mud were, no doubt, toys with which, as rattles, the mothers amused their little nurslings.

Other discoveries have been made which show that agriculture was somewhat advanced among the lacustrian tribes of this first period, and we should consequently assign them a much more elevated rank than was originally supposed. Doubtless hunting and fishing supplied the greater part of their food, as is indicated by the very situation of their homes in the midst of the waters, and by the bones, partly devoured, of the urus, the bison, the deer, the elk, the roe, the chamois, and birds of the woods, which are found in the beds of turf or mud of their ancient habitations. Wild fruits also furnished a portion of their aliment, as there have been found amongst the

remnants of their fare pine and beech nuts, walnuts and seeds of the raspberry; but at the same time they reared herds of beeves, sheep, goats, swine, and were accustomed to employ the dog as a substitute in the care of their domestic animals. They manufactured a kind of cheese in vessels pierced with holes, cultivated the apple, pear, and plum tree, and stored away their fruit for the winter. They sowed barley and different sorts of grain of excellent quality. Among the ruins of a lacustrian village, on the lake of Constance, M. Löhle has discovered an ancient storehouse, containing about a hundred measures of barley and wheat, both shelled and in the ear. He found likewise a portion of real bread, which had been preserved by its carbonization, and consisted of crushed grains, to which the bran still adhered. Thus, with the exception of poultry and eggs, the food of the primitive inhabitants of Helvetia in all respects resembled our own.

The possession of the cereals, those humble plants which constitute the most important acquisition of the human race, would, of itself, suffice to prove that the nameless tribes of the age of stone might lay claim to a long period of past progress. The attentive exploration of lacustrian villages has shown that their inhabitants also practiced on a large scale what we call the *division of labor.* Certain localities, in fact, such as Moosseedorf, Obermeilen, and Concise, present so great a profusion of implements, some finished and others simply rough-hewn, that we cannot help recognizing those settlements as real places of manufacture. They were the industrial cities of that era, and each of them exercised a peculiar specialty, which implied a considerable system of exchanges between the different centres of production. There must have existed also no unimportant commerce with distant countries, for there have been found on the lacustrian sites a great number of substances foreign to Switzerland. The rocks of the neighboring mountains, the horns of deer and bones of wild animals might have served, it is true, for the fabrication of almost all the implements; but the projectile arms, made of silex, could have come only from Gaul or Germany. By exchange from one hand to another, the lacustrians received coral from the tribes of the Mediterranean, purchased yellow amber from the dwellers on the Baltic, and imported the valuable nephrite from the countries of the east. Those among the learned who believe in the Asiatic origin of all nations may assume that the lacustrians had themselves brought from Asia a considerable quantity of nephrites; but how could they have obtained the silex, amber, and coral, unless by commerce? People who pursue the chase do not fear expeditions which shall last for weeks and months. Thus it was that before the arrival of Europeans the Indians of the great lakes were in constant communication with those of the lower Mississippi. Whether with a view to traffic or to form alliances against enemies nearer at hand, they fearlessly undertook journeys of prodigious extent across the savannahs, the forests, and the great rivers.

If their agricultural knowledge, their industry, and their extended commerce were of a nature to raise in the scale of races these primi-

tive tribes, whom we should have been tempted at first to consider but little developed, their religion—that is to say, the highest expression of their genius—bore also a good testimony in their favor. Like the Celts, the lacustrians seemed to have adored the Divinity in open nature, on the summit of hills, under the mysterious shades of the wood, on the bosom of the waves, or more especially at the foot of the erratic blocks, which they doubtless regarded as stones fallen from heaven. Most archæologists do not hesitate to attribute to them the erection of a great number of menhirs and other stones, improperly designated under the general term of druidical. The most considerable of the tumuli of Switzerland equally pertain to the first age, for they never enclose any relics but those of the primitive industry, without a trace of metal. The remarkable elevation of these tumuli, which often rise from 10 to 20 and even 30 metres in height, seems to prove that the men of the age of stone cherished a profound respect for their dead. These were deposited in the sepulchral cavity, with the arms folded across one another on the breast, and the knees drawn up beneath the chin, as if to testify by this attitude—which is that of the infant before birth—that man in dying enters into the womb of the universal mother. Even recently some communities of the Alpine valleys observed an affecting ceremony in their funeral rites. When the tomb was just closed, the mothers drew near to shed a drop of their milk on the freshly-stirred earth. It is perhaps to the age of stone that we should attribute the origin of this custom. In no instance has there been found any vestige in the tumuli of this era which would authorize us to suppose that the aborigines of Switzerland had ever sacrificed human victims to the manes of their dead. Those ferocious rites, which the Helvetians of the age of iron celebrated at a later period, were completely unknown to the lacustrians.

To what periods of history must we refer that age of stone revealed to us in the deposit of archæological remains in the lakes of Switzerland? In this we have one of the first questions which presents itself to the mind. M. Troyon sought at first to resolve it by studying the formation of the turf on the sites of different lacustrian villages. By an ingenious process, which recalls that of the botanist computing the age of a tree from the number of its concentric rings, he endeavored to establish the age of the accumulations of implements and utensils at the bottom of the lakes by determining how many centuries have been required for the deposit of the superposed layers of turf; but, unfortunately, the production of the turf is effected with more or less slowness, according to laws not yet known, and M. Troyon has been obliged to recur to another mode of determination, which was furnished by the lacustrian villages of western Switzerland.

Under the alluvial strata deposited by the torrents which discharge themselves into the lakes of Geneva and Neuchatel there have been discovered numerous groups of piles dating evidently from the age of stone. An ancient lacustrian site of this epoch is found near Villeneuve, at more than 450 metres from the present shore of Lake

Leman. There have been also recognized traces of villages of the same age on different points of the alluvial deposits of the Neuchatel basin: at the mouths of the Mantua and the Reuse; in the midst of the marsh of the Thiele, and chiefly in the marshy valley of the Orbe, which stretches to the south of the town of Yverdun. In order to know the age of these piles buried under the deposits of alluvium, it suffices to measure the distance which separates the present bank from the ancient one, and to find between these two concentric lines a given point of which the age is known, and which may furnish an approximate estimate of the rate of progress of the alluvium. This point exists in the valley of the Orbe: it is the site of the ruins of the ancient gallo-Roman city of Eburodunum. Between the down on which they rest and the lake, on the space partly occupied by the town of Yverdun, there is found no vestige of Roman antiquities; and we may thence conclude that, at the commencement of our era, the shore of the lake approached much more nearly to the foot of the down. Admitting that its waters bathed the walls of the *castrum eburodunense*, it would have required at least fifteen centuries for the formation of the zone of 800 metres in extent, which lies between the ruins and the shore; but it is highly probable that the retreat of the waters has not been so rapid, for the Celtic name of Eburodunum testifies in favor of a more ancient establishment than that of the Romans. However, if we accept as a point of comparison this datum of fifteen centuries, (evidently too little,) we perceive that another period of eighteen centuries must have been necessary for the filling up of the space of 1,000 metres which separates the down from the ancient piles situated to the south, at the base of the hillock of Chamblon: thus we are carried back to the fifteenth century before our era. At the latest it was at this epoch, and, perhaps, long before, that the lacustrian village of Chamblon, invaded by the turf and the alluvium of the Orbe, must have been abandoned by its inhabitants. In order to arrive at the epoch of the foundation, it is still necessary to ascend the course of ages, and to add some centuries for the filling up of the strait which separated the village from the ancient shore, still easily recognizable at the foot of the isolated little hill. While acknowledging that these figures establish nothing absolutely, M. Troyon is led to fix the construction of the lacustrian habitations of Chamblon by the primitive colonists of Helvetia at two thousand years before the Christian era. It might, perhaps, be objected that the level of the lake may have sunk considerably during the historic ages, and have left dry the marshy plain of Yverdun; but the ancient shore is situated at exactly the same height with the present shore. The level of the lake has, therefore, remained the same during the last forty centuries of history.

The result to which M. Troyon has been conducted by the examination of the alluvial deposits of the valley of the Orbe seems to us one of the greatest triumphs of geology. This science, which had already taught us the relative age of the fossil plants and animals of our globe, serves now to determine the critical chronology of the races of men which have succeeded one another on the surface of the

earth. Where historical monuments and written testimonies fail, there it is that the function of the geologist begins. He explores those beds deposited by the waters one grain of sand after another; he exhumes the gnawed bones, the pottery, the relics of every kind long stored up in the archives of the strata; and the examination of these objects suffices him for the retrieval from oblivion of engulphed populations. Thanks to his researches, the history of man in the countries of western Europe is removed backward two thousand years. Henceforth it is a fact assured to science, that a race of hunters, of agriculturists, and of artisans, lived in Helvetia eight or ten centuries before the war of Troy, and commenced with the tribes established in Germany and on the coasts of the Baltic. The field of natural history is equally aggrandized; for, if the mammoth and other animals cotemporary with the races of men had long disappeared, the bison, the great elk, the wild goat, the beaver, still inhabited the forests of central Europe. Finally, we learn a fact of the greatest importance for the history of the globe itself, namely, that the climate of Helvetia has not sensibly varied since four thousand years ago. The trees and plants which grow to-day in that region grew there then; the same fruits, cultivated and wild, served for human aliment; the sole difference revealed by the study of the remains of the age of stone is, that the water-caltrop *(trapa natans)* and the dwarf water lily, which exist no longer in the lakes of Switzerland, then grew there in abundance. This equality of climate during a period of forty centuries is a serious objection to the hypothesis of polar deluges first proposed by M. Adhémar, and since developed by MM. Le Hon and De Jouvencel.

II.

Articles made of metal were not absolutely unknown to the lacustrians at the close of the first age, as is shown by some relics found at Obermeilen and Concise; but the perfection, as well as rarity of the objects discovered, evince that they came from abroad, whether in the way of exchange or through the chances of war. It would be absurd to suppose that those primitive tribes had proceeded fully prepared to the fabrication of bronze without having previously availed themselves of copper and tin. The phenomenon of an alloy of the two metals can only be explained by the arrival of a new people bringing with them a new civilization. In Hindostan, in Central Asia, in America, the age of copper succeeded slowly and gradually to the age of stone—the age of bronze, in turn, replaced by degrees the age of copper; but in Helvetia, as well as in all western Europe, this latter period is not represented: the bronze abruptly follows the stone. It is because two races had come into collision. The end of the first age must have been marked by terrible events. In almost all the lacustrian villages the verge of the two epochs is sharply indicated by the burning of dwellings and the massacre of the people. The intruders, probably of the Celtic stock, wielded axes of metal, and by virtue of the superiority of their arms

must have had their own way with the poor natives—just as the Spaniards mastered the Indians with ease when they invaded Mexico and Peru, mounted on fiery steeds and launching death from a distance.

It would seem that the lacustrian population of eastern Switzerland suffered most from the conquest. The greater part of the pile-work settlements of that region were completely abandoned, and since that epoch their remains have been buried beneath the waters. The aquatic villages of western Switzerland equally exhibit distinct traces of conflagration; some, such as the celebrated Steinberg, (mountain of stones,) situated in the lake of Bienne, were reconstructed on the same site; others, after their destruction, were rebuilt at a greater distance from the shore, so as to be beyond the reach of incendiary projectiles; in fine, numerous groups of habitations were reared on the shallows, till then unoccupied, of the lakes of Geneva, Neuchatel, Bienne, and Morat. At the commencement of the age of bronze, the lacustrian population of the country seems to have removed in mass to escape the vicinity of the enemy who had seized upon the whole of eastern Helvetia, now occupied by the Swiss, who speak the German language. Withdrawn into the territory which forms the present French-Switzerland, the lacustrians were fortunate enough to repress all invasions, and at the same time to appropriate all the industrial secrets which their conquerors had brought with them from the east. Thanks to this contact with a more civilized race, a new era of prosperity seems to have opened for them, and the census of the lacustrian population largely increased.* The villages of the age of bronze much surpass in number those of the preceding period, and in the fens of the Thiele, between the lakes of Bienne and Neuchatel, the piles are found in such quantity as to have given rise to an actual trade in wood.

The wear and waste, more or less complete, of the posts suffices in general to indicate whether the villages whose sites have been recognized pertained to the age of bronze or that of stone. Almost all the piles of the more ancient epoch have been wasted away by the waters to the very surface of the ground, while those of the second period still project to the extent of one or even two metres. In general, the lacustrian constructions underwent no change of form, doubtless because the customs of the people had remained the same; yet M. Troyon also mentions cabins built on rafts, and habitations similar to the huts of the Bosphorus, perched, at different heights, on long poles oblique and crossed like the interlaced boughs of a tree. As to the choice of sites there is apparent, in the second age as well as the first, a rare sagacity. The points of the shore over against the places colonized by these old lacustrian tribes have, for the most part, not ceased to be occupied even to our own day by cities or

* By measuring the dimensions of fifty-one aquatic settlements of the age of stone, discovered in 1860, M. Troyon computes that the total populatiou of the lakes amounted to 31,875 persons. By an analogous calculation, sixty-eight villages of western Switzerland, constructed during the age of bronze, would have contained a population of 42,500 inhabitants.

important villages. The city of Zurich covers a lacustrian settlement of the age of stone; during the age of bronze a village on piles might have been seen on the site of the present city of Geneva.

Once in possession of metal, industry attained a great superiority over that of the preceding period, but a resemblance subsists in the form and nature of its products. The axe continues to be the faithful comrade of the warrior, and the artist employs all his skill in decorating it. To this arm of battle new instruments of death are added, the sword of bronze and the mace of stone; but arrows have become very rare, which proves that instead of engaging in combat at a distance, like their fathers, the natives were accustomed to march straight up to the enemy and fight face to face. They had not forgotten the use of incendiary projectiles. Among the industrial remains of that age we find in like manner knives, reaping hooks, stones for grinding and sharpening, needles, pins, weaver's shuttles, fish hooks, quoits, toys, ear-drops, ornaments in rock crystal, pieces of amber, necklaces of glass and of jet. The potter's ware resembles that of the age of stone, and is composed of an analogous paste, mixed most frequently with small silicious pebbles. Yet the art of the potter has made incontestable progress: the variety of forms is greater and the ornaments more numerous. All the settlements of any importance had their manufactory of earthenware, as is proved by the specimens which have been disfigured in baking and rejected as unmarketable. There were special manufactories for instruments of bronze, for an elegant mould for hatchets has been discovered at Morges and real founderies at Echallens, in the canton of Vaud, and at Dovaine, near Thonon. Moreover a bar of tin which was taken from among the piles of Estavayer proves that the bronze was not imported from abroad in a state of alloyage. The people of Helvetia knew how to procure raw metals, and those valleys of the Alps, which even during the age of stone had been a centre of commerce, on the one side with the Baltic and on the other with the Mediterranean, now exchanged their products with the islands of the Cassiterides. Agriculture developed itself simultaneously with commerce, and it was probably to the progress made in the production of alimentary commodities that the population owed its marked increase. The breeding of domestic animals equally augmented in importance, and the horse, scarcely represented in the age of stone, appeared now in numbers.

The advances of the lacustrian colonies appear not to have deeply modified their religion. After the invasion of the Celts, the priests, faithful to ancient usages, rejected the metal introduced by the profane tribes, and continued to make use of instruments of stone, as in the primitive age. The erratic blocks ceased not to be true altars, as is testified by the numerous objects brought together from neighboring settlements occupied only during the age of bronze: among these venerated blocks are cited the stone of Cour, situated in Lake Leman, below Lausanne; the stones at Niton, which form islets at a short distance from Geneva, and not far from Estavayer, in Lake Neuchatel; the Pierre au Mariage, on which, even in the last century, the betrothed went to swear mutual fidelity. If the religion of the

lacustrians underwent no change during the age of bronze, it is nevertheless probable that their zeal gradually diminished in consequence of their ever-increasing relations with their neighbors, the Celts. The tumuli which they raised during the second period are much less high than those of the first age, and their dead have no longer the folded position of the embryo in its mother's womb; they are simply seated or even extended on the ground. The lacustrians never adopted at least the custom of the incineration of the corpse, which the Celts had imported from the east, and which, in the religious sentiments of the former, must have seemed a crime against the dead.

The duration of the lucustrian settlements of the age of bronze was very long, if we judge of it from the thickness of the beds of remains and the great difference of the waste which appears in the piles planted at different epochs on the same site; but the destruction of these settlements was as violent as that of the aquatic habitations of the preceding age, for what remains of them under the surface of the waters incontestably bears traces of pillage and conflagration. A new people, armed with blades of iron, invaded the vast undulated plain which stretches between the base of the Alps and that of the Jura, and after a war of more or less duration, finished by possessing themselves of the wooden fortresses in which the lacustrians had taken refuge. The catastrophe was nearly total, for, of seventy or eighty villages which existed in the second age, eleven only present traces of the following age, and of this number we can scarcely count three of them which give indications of a prolonged occupation. The lacustrian villages of Steinburg and Graseren, in the lake of Bienne, and of La Tene, in the lake of Neuchatel, were the only important localities in which the primitive population could seek a refuge. Perhaps some families of the vanquished might have become allied with those of the invaders; but it is probable that the great mass of the aborigines was destroyed or was forced, as a herd of slaves, to adopt the customs of the Helvetian conqueror. The people disappeared, and history has not even recorded their ruin. The lacustrian villages, which had been during the course of so many centuries the residence of a powerful race, were replaced by miserable huts, where the families of fishermen, suspended above the waves, sought a meagre existence. Some remains of rude pottery, dating from the Roman epoch, show that these aquatic abodes were still inhabited at the commencement of our era.

The destruction of the greater part of the lacustrian villages having taken place when iron began to be diffused through the country, we are enabled to fix the epoch of invasion within the limits of a few centuries. The Phocæans of Massilia and the Belgic Cimbri, emigrants in the north of Gaul, had introduced the use of this metal, the former from the commencement of the sixth century, and the latter during the fourth century before the Christian era. By their means iron arms must have soon superseded those of bronze among a great number of the tribes with whom they had commercial intercourse. Thus, towards the fifth or fourth century, iron, the true metal of war, was more or less known to the Gauls, and perhaps the Lacustrian

tribes had already received swords of iron, with other products of industry, from the Phocæans or the Cimbri. Yet the use of arms of bronze was still general when the aboriginal races, attacked by a people with superior arms, sunk in an unequal strife. The invaders are known; they could be no other than the Helvetians of Gaul or of southern Germany. All the testimonies collected by archæologists agree in identifying their Gallic origin; the Celtic denomination of their villages; the form of their arms, identical with those worn by the Gauls of Brennus during the occupation of Rome; the crescents which they bore as amulets; the practice, in a word, of burning their dead.

The Helvetians were certainly superior to the primitive people in the material part of civilization. The lacustrian deposits of the two first ages offer nothing comparable to the thousands of objects which have been discovered at Tiefenau, near Berne, in the soil of a field of battle of the Helvetian period. Not only did they possess iron and forge swords, which might even now be considered master pieces of art; they also produced glass and enamel, fabricated ornaments of great richness, and, if we believe the testimony of Latin authors, were acquainted with the art of writing. Unfortunately this people, so remarkable for their industry, professed a barbarous religion. There are still to be seen, in different parts of Switzerland, the remains of their sacrifices of human victims. Not far from Lausanne, in the forest of Bois-Genou, rises a tumulus which covered four earthen vases filled with human ashes. A cavity formed above the urns contained the charcoal and cinders of the funeral pile, as well as the calcined remains of animals, among which were recognized the dog, the ox, and the horse. Still higher there was spread "an uneven bed of large, rough stones, on which lay, without order, four human skeletons, whose irregular position showed that the bodies had been thrown with violence on this rude couch. Bracelets, remnants of small chains, brooches, and various ornaments indicated the attire of females, whose youth was evidenced by the incomplete development of the wisdom teeth, still hidden within the alveolus. The limbs of these unhappy victims had been broken by the stones which covered them and which had been cast with such violence that a portion of the ornaments had been shattered by the shock. At a distance of two hundred paces from the tumulus still exists an altar on which, without doubt, the immolation of the wives of the deceased had taken place." Again, at the further distance of two kilometers there was found, under the shade of oaks another tumulus of the Helvetian era, containing twelve skeletons of young persons crushed by blows of the club.

We know that after a sojourn of some centuries in the valleys of the Alps and of the Jura, the Helvetians, always restless and desirous of change, left their mountain country to go to establish themselves in the plains of Gaul. It was then that, for the first time, they enter upon the theatre of history, properly so called, thanks to Ceasar, from whom they sustained, at Bibracté, a bloody defeat. The archæological discoveries made in various parts of Switzerland enable us

now to ascend the course of time and to reconstruct, in its general features, the history of the Helvetians up to about the fourth or fifth century of the ancient era; but if the chain of ages is reunited for this Gallic tribe, it is not so for the lacustrian colonies, whom the Helvetians had exterminated or reduced to slavery.

What were these aborigines whom archæology has, as it were, resuscitated by an examination of the remains found in the mud of the lakes? Were they of Finnish, Sicilian, Iberian, or Pelasgic origin? Should we seek their native country on the table-land of Iran, or on the soil of western Europe itself? One thing only seems certain, that they were men of small size, more remarkable for their agility than their force. Their narrow bracelets could only encircle delicate arms; their swords, with short handles, could not have been grasped by the large hands of the Gauls and required a certain skill in fencing; in viewing them one might say that they had been wielded by agile warriors like our basque soldiers. Nothing, however, as yet, authorizes the learned to give a definite answer. The form of the skull of the lacustrians would be a datum of great importance in the question, but the skulls and other bones found on the lacustrian sites and in the tombs of the age of stone are rare and offer only remains which it is difficult to study. By a singular contrast, we know the origin, the wars, the migrations, and even the royal genealogies of many ancient people whose manners are unknown to us; and here we have tribes who reveal to us their intimate life, their domestic habits, and who make a mystery of their name. Their productions are collected in our museums, we have been able even to draw up their statistics in an approximative manner, but they pass before us in history like apparitions, and we know not how to connect them with any of the races which precede or which follow them. Let us hope that in the near future the methodic exploration of the antiquities of Europe, and the comparison of all the testimonies furnished by the still buried remains, will enable science to class the lacustrians, to follow their migrations, and mark their halting places. Already have recent discoveries established, in a positive manner, that they also inhabited the lakes of Savoy and upper Italy. We shall, doubtless, succeed in ascertaining what was the extent of their domains at different ante-historic epochs, and, what is even more important, their intimate life; their moral civilization will be elucidated by a thorough study of the tribes which have sustained a development under parallel conditions in different points of the globe, and which still exist in an age of stone and of lacustrian habitations. It is then that we may attempt to write the comparative history of adolescent races—one of the most interesting chapters of the great book of man.

While awaiting the results of systematically organized researches on all the continents, we should highly congratulate the scientific explorers of the lakes of Switzerland on having recovered these humble remains, so long hidden under the waters. These relics also speak a language not less eloquent than that of the great monuments left by the Roman conquerors. The nations whose life is recounted

by all the voices of history are not the only ones which have exercised a great and durable influence on their successors; the savage or barbarous tribes forgotten by the fugitive memory of their descendants have also accomplished their work. Even yesterday, before the piles had been observed through the transparent water of the lakes, we knew nothing of that nation which, during perhaps twenty centuries, had prepared our soil for the civilization which it this day sustains. It is that which contended with the ferocious beasts, cleared the forests, cultivated the earth; it is that which performed the great work of first colonization attributed by the Greeks to their demi-gods. The heroes of Gaul do not bear, like those of Greece, the glorious names of Hercules and Theseus; but, though fallen into oblivion, they have not forfeited their right to our grateful recognition. The living generations are joint heirs with those which have long since disappeared, and in the estimate of our vaunted modern civilization a large share should undoubtedly revert to the tribes without a name of the ages of stone and of bronze.

ELISÉE RECLUS.

THE FAUNA OF MIDDLE EUROPE DURING THE STONE AGE.

BY DR. L. RÜTIMEYER: BASEL, 1861.

[Condensed from the German.]

To the ante-historical eras, which cannot be measured by solar years, the names of stone and bronze age are applied. By these expressions periods are indicated in which certain nations made their implements—whether for domestic, hunting, or agricultural use—of stone, or, later, of copper or some alloy of this metal, but never of iron. Though in the case of some of the ancient nations the time when they changed their implements of stone for those of bronze can be determined chronologically, in general, we can only say that one period succeeded another, as the geologist speaks of older and newer strata, without being able, however, to state any definite periods of time.

Among the most remarkable relics of the stone age are the supposed Celtic implements of flint which have been discovered in the tertiary debris of Amiens and Abbeville. Of later date are the relics of the lacustrine remains in Switzerland. They are found either under the surface of the waters of the Helvetian lakes, or, partly overgrown with turf, upon the ancient beds of inland lakes. The primitive people built their dwellings upon palisades either partly or entirely in the water; and hence the name sometimes given of "palisade buildings." Mingled with the remains of these buildings, historical records are found, in the form of implements of

the ancient people; and also bones—in most cases the remains of ordinary meals or festive celebrations. From these documents we learn that the ancient people spun and wove cloth garments, and also that they produced pottery by hand.

If any one should have taken the trouble to gather up all these bones, and to submit them to anatomical comparison, he could have advanced various branches of science. He could have enabled the archæologist to show which of the animals were hunted and which were reared by those people; he would have also assisted the anatomist to discover what changes had taken place in skeletons of animals during very long periods of time; he would also have furnished the geologist with the means of determining which species and genera had lived contemporaneously in one or the other locality; he even would have presented facts to enlighten the zoologist as to the interesting and exciting but very difficult questions regarding the origin of species and the possible mutability of types; and, finally, he could have given interesting materials to the husbandman tending to throw light on the history of the more important domestic animals. All these desiderata have lately been most successfully, though modestly, furnished by Professor Rütimeyer, of Basel. A short abridgment of his work may not be without interest; the more so as the results arrived at by this Swiss savant are helping to penetrate the barrier which heretofore has separated history from geology.

The antiquarians of France, remarks Rütimeyer, find stone axes in the mammoth strata of Bretagne; and in the Swiss palisade buildings occur the diluvial bovine species—*Bos primigenius* and *B. trochoceros*—both domesticated.

Among the bones of the lacustrine habitations 66 species of vertebratæ were recognized, viz: 10 of fishes, 3 of reptiles, 17 of birds, and 36 of mammals; 8 domesticated, to wit: of the dog, the hog, the horse, the ass, the goat, the sheep, and at least of two bovine species. Among these neither the bones of chickens nor of cats are found. Predominant above all are the bones of the stag; after these those of the cow. This proves that the chase furnished the principal portion of the food. The bones of hogs appear numerically third in rank. These animals seem to have been more in use as game than as domesticated stock. Still more rare are the bones of deer, goats, and sheep. In later settlements the latter commenced to prevail over the goat. The dog appears quite scarcely represented, as is also the case with the horse and the donkey. The bear, the wolf, the auerox, the bison, the elk, the chamois, and the ibex seem to have served occasionally as game.

Critical comparison enabled science to distinguish the bones of wild from those of domestic animals. Those of the former exhibit a deep brown, almost black, color; a surface smooth and greasy to the touch, and in most cases a wonderfully increased specific gravity; more distinctly marked carinæ; greater roughness, and more acutely cut muscle insertions—in short, the greatest possible distinctness of all the edges and protuberances, together with the least possible

quantity of indifferent surfaces. On domestic animals the bony substance appears—if the expression may be allowed—more soft, spongy, and yielding to plastic impressions. We cannot doubt, says Dr. Rütimeyer, that the new relations of life following the domestication of animals causes a weakening of all the energies of the system, by increased nourishment, and lessened exercise, and additional fattening. These are the results, not of centuries, but of much shorter spaces of time.

It is not to be wondered at if we find the remains of the bear, the badger, the stone marten, the tree marten, the pole-cat, the ermine, the otter, the wolf, the wildcat, the hedgehog, the squirrel, and the woodmouse; for all these animals inhabit the country even now. It is very remarkable, however, that the fox, during the palisade age, was much smaller than he is now, attaining then only in few cases the average size of what it is at present. Since the ancient times this species has grown one-third larger. The dimensions of animals are thus changeable; but this instance must be considered in connexion with others to be mentioned, in which the size has been considerably diminished.

Of the common rat no traces were found, and we know that this animal immigrated into Europe as late as the middle age; the Asiatic wandering rat is also absent; therefore during the stone era no mammal vermin infested the palisade settlements.

Of the hare only one single relic has been discovered, and we may with some propriety conclude that among those ancient people the eating of this animal was prohibited.

At the time of the palisade buildings the beaver still existed in Switzerland, and maintained itself up to 1846 in the river Leeh. It was even found in 1857 at the mouth of this river. If this interesting rodent could have been protected by state laws, its existence would have been extended a few generations more. The beavers would, however, have died out, for these harmless animals can only exist in complete solitude. How large the distribution of beavers must have been in Bavaria is shown by the fact of the existence of sixty chronographical names which are combined with the word beaver.

During the palisade era, three races of swine (*Sus scrofa, L.*) were in existence, viz: the domesticated, (*S. sc. domesticus,*) the same in a wild state, (*S. sc. ferus,*) and the turf hog, (*S. sc. palustris.*) The latter race was then found wild and also domesticated, but ceased to exist in its former state during the historical time.

The ancient wild hogs were distinguished from their present descendants by a much superior size, and generally by the more prominent characters by which they are distinguished from the domestic hog.

The characteristic of the turf hog as a distinct race lies in the teeth, especially in the eyeteeth and also the tusks. The latter are much smaller than those of the domestic and the common wild hog; they also remain three-edged when old, while those of its congeners become gradually cylindric. The turf hog still exists in several valleys of Rhätia and Granbünden.

The stag, (*Cervus elaphus,*) now extinct within the limits of the

lacustrian habitations, furnished the ancient Swiss with by far the greater part of animal food. The size of this animal was extraordinary, exceeding in height even our largest horse.

The elk was also well represented, and maintained itself on the Rhine down to the tenth and eleventh centuries.

The ibex (*Capra ibex*) was found only once, notwithstanding the little town of Unterseen, in the canton of Bern, carries the figure of this animal in its coat-of-arms.

The chamois is also rare, and it is probable that this and the former were brought only occasionally from the mountains down to the less elevated regions.

The bison (*Bos bison*) appeared quite frequent all over Switzerland during the stone age, but still more common was the auerox (*Bos primigenius*,) which, during those times, long passed, was one of the oldest and most constant inhabitants of Switzerland. He existed there in company with certain pachyderms, whose congeners since have receded to Africa.

In the schieferkohle (*slate coal*) of Dürnten (C. of Zürich) most complete remains of *rhinoceros leptorhinus* were found, lying side by side with the teeth of *Bos primigenius* and *Cervus elaphus*. While this *pachyderm* had long ceased to exist in Switzerland, both its contemporary ruminants held out there until a people arrived which spun and wove the fibre of the flax, and reared and milked the progeny of the auerox.

In the lower beds of the drift which, thirty feet thick, overlies the coal of Dürnten, the remains of an elephant are found, which are not only distinct from that represented in the coal, but which never have been discovered lying together upon the same horizon. Higher up, this drift consists of debris of glaciers with remains of marmots and reindeers. Upon an area of but few miles circumference, and within a vertical of only thirty feet, we thus find, first, the auerox associated with Elephas antiquus in the coal of Dürnten; afterwards the auerox and the mammoth, in the diluvium of the valley of the Rhine; still later reindeers and marmots, of which the one now is removed from twenty to twenty-five degrees northward, and the other has ascended to the more elevated alpine zones. Finally, on the top in the higher situated turf of Robenhausen, the auerox again appears in company with *Bos bison* and *Cervus alces*.

These are, indeed, extraordinary changes, and it is not improbable that the human species witnessed and suffered under them.

In regard to birds, reptiles, and fishes, the ancient fauna differs but little from that of our day. It is worth noticing, however, that from the condition of the bones of the wild swan we must infer that these birds must have been eaten by the ancient Swiss. It also proves that the lacustrine habitations were not mere summer residences, but must have been occupied also during the cold winter season, when the lakes were frozen over, at which time alone the swan appeared so far south.

The rarest domestic animal of palisade age is the dog, which was occasionally eaten, but was used more commonly to assist in hunting. It is a very remarkable fact, however, and important for the history

of the canine family, that during the whole era of the palisade builders but one single race can be found, which, according to its unvarying characteristics, is identical with that of our pointer. The hog, as a domestic animal, was first wanting during the palisade era; afterwards the turf hog (*Sus scrofa palustris*) appears domesticated before the progenity of the common wild hog (*Sus scrofa ferus*) was raised to that honor.

The horse was exceedingly rare, so much so that we must conclude that this animal was not domesticated by the palisade builders, but was introduced only occasionally perhaps among war spoils.

Of the tamed bovine family a type appears locally limited, which approaches the fossil species of *Bos trochoceros* from the diluvium of Arezzo and Sienna, in Italy. A peculiarity of it is the direction of the horns, which, instead of the three-fold curvature which the auerox exhibits, describe a simple arch in one and the same plane. This race afterwards disappears from Helvetian ground, as also does that of *Bos primigenius*, which has the auerox for a stemholder. The former, however, is preserved in the sub-race of Friedland, Oldenburg, and Holland. The third race of the palisade era, *Bos brachyceros* (identical with *Bos longifrons* of Owen) is considered by Dr. Rütimeyer the same as the so-called "*Thurfox Thurfcow*," a race which, under the name of brown cattle, is still found in the counties of Schwyz, Wallis, Obertrasts, and Granbünden. The same anatomist also favors the views of some modern cattle-breeders who recognize among the endemic stock only two races, which are said to hold on to their geographical distribution with the utmost tenacity. The stock-breeders there regarded always only external and seemingly trifling but at the same time very constant characters, and their sagacious suggestions have been fully sustained by the latest osteological researches.

The first and older race is the so-called "*Braunvieh*" (brown cattle,) *Bos brachyceros* of a natural or deer color, without any purer tint and especially lacking in pure white, but otherwise exhibiting every shade from light gray to a dark blackish brown. A peculiarity of this race is also the colors of the hair, which never appear distinct, but invariably run into each other.

The other race is the spotted or speckled, which did not exist among the palisade builders, but was introduced from the north within historical times. It originates from *Bos frontosus*. This race is preserved in its purest state in Saanen and Simmenthal. To it also belongs the black and white spotted race of Fryburg. The pure colored, spotted, or speckled race always shows either uniformly red (bay) or sorrel or black, or white and bay or sorrel, or white and black. One individual showing all three colors is only an exception to the rule.

Of human remains but one skull was discovered. If this should really belong to the palisade age, and if we could be permitted to base a conclusion upon one single specimen, we would say the cranial type since those days has suffered no change, or the palisade builders did not differ osteologically from the Swiss of our own days. It seems the ancient Helvetians did not leave their lacustrine habitations until

the time of the first invasion of the Romans, when probably this singular mode of habitation was abandoned.

We also received by Dr. H. Christ an account of the flora of the palisade age, which presents some noteworthy phytographical results. There were found changed into a hard shining coal with a metallic lustre on the surface well-developed unwrinkled remains of wheat, resembling our *Triticum vulgare*, but much smaller. The grains of our modern wheat measure from seven to eight millimetres, while those of the ancient wheat are only from four to seven millimetres in maximum length. The spike of the ancient wheat is much more full and crowded, whereby the spiculæ are forced into an almost horizontal position.

Hordeum hexastrilmus is also found, but *Triticum spelta*, oats and rye, have not been noticed. Thus it appears that wheat, even in our more northern regions, was the oldest cereal in cultivation. One species of *Linum* has also been found with the seeds and capsules most perfectly preserved. It approaches *L. montanum* and also *L. perenne*, but is unlike our *usitatissimum*, the native land of which has not yet been discovered.

Of hemp (*Cannabis*) no traces have been discovered, and therefore the ancient Swiss could not have immigrated from a region where this plant is indigenous.

Apples cut in halves, and probably prepared for preservation, show by their kernels, capsules, and general outlines, a size surpassing that of the modern form of *Pyrus malus*, as represented in the Swiss mountains.

Of pears but one doubtful piece was obtained. A species of *Prunus* (*spinosus*,) perhaps the plum (*P. insititia*,) and sweet cherry, were present. Among the forest trees the presence of the dwarf pine (*P. maghus*) in the lowlands is remarkable because this species has since retired to more elevated alpine and sub-alpine regions. It seems generally that since the palisade era the flora has undergone no material changes, which is contrary to the observations made in Denmark, where the remains of turf exclusively contain but pine and afterwards oak, where now the beech constitutes unbroken forests. This proves some kind of natural rotation, but it is erroneous to suppose that the growth of leafy trees of necessity must be preceded by the lower organized conifers.

Since the palisade age various aquatic plants have receded to the mountains; for instance, *Nuphar pumilum* and *Trapa natans*, which latter now only occurs at Langenthal and Elgy. This change of habitat deserves the more consideration as there is no ground for the belief that the migration of these plants has been influenced by man.

It is as yet impossible to fix the time of the lacustrine habitations chronologically. The last period of it, when the turf hog in its wild state had ceased to exist, and the older bovine races (*Bos trochoceros* and *B. primigenius*) had been replaced by the northern spotted cattle, (*Bos frontosus*,) which announce the period of domesticated races, pertains to historical times. The chronological space backward towards the oldest remains of the palisade age cannot be estimated; it ought not to be measured even with the unlimited scale of geological periods.

The builders of the palisade habitations could not have arrived in Switzerland before the glacier era, which forced the elephant and the rhinoceros far down into Africa, and drove the marmot and the reindeer into the Swiss lowlands. But when middle Europe was warmed up again by sunnier days, a repopulation by a partly new fauna and flora took place upon the ground where before the reign of the glaciers, the auerox, and those large pachyderms, had been grazing together. At this time man made his appearance, accompanied by the dog, the goat, the sheep, the domesticated auerox, and the turf cattle; the latter he may have introduced already tamed, or he may have tamed it after he had found it there in a wild state.

The lake inhabitants of Wangen and Moosedorf, therefore, were not autochtons, in the strict sense of the word, and it is even doubtful whether another race did not inhabit middle Europe before them, and even anterior to the glacier age; for recently there were discovered in a cave near Aurignac (Hautegaronne) seventeen human skeletons, with a number of bones of the mammoth and a contemporaneous rhinoceros, besides those of many other animals. Some of these bones had been artificially opened by human hands for the sake of the marrow—similar to bones which were found under the lacustrine habitations. Those bones in France also exhibit the marks of the teeth of the cave tiger and the hyena spelæa; of both these animals also numerous bones have been found. Remains of the auerox, the reindeer, and the stag were also found there. Thus science has at her disposal the relics of predecessors, witnesses, and followers of the glacier era. Even the horse and the ass were found to be represented there; only the dog is looked for in vain.

On the strength of this fact Dr. Rütimeyer concludes that man existed before the glacier era, having domesticated at the time several animals, while the elephant and the rhinoceros existed in the regions of middle Europe.

REPORT UPON THE ANTIQUARIAN AND ETHNOLOGICAL COLLECTIONS OF THE CANTONAL MUSEUM AT LAUSANNE.

BY FRED. TROYA.

[Translated for the Smithsonian Institution.]

MR. PRESIDENT AND GENTLEMEN: The collections of the Cantonal Museum, which you have intrusted to my care, are those of antiquities and ethnology, on which, in compliance with your circular of the 19th instant, I proceed to report.

The collection of antiquities includes objects of very various origin which may be classed under two general heads, namely, of Swiss antiquities and foreign antiquities. The Swiss antiquities quite

naturally fall into subdivisions corresponding to the various ages to which they belong; the others, few in number in comparison, are classed according to the countries from which they come.

The interest that attaches to these relics arises not merely from their greater or less antiquity, or from their art, more or less perfect, but far more from their being the expression of the different degrees of ancient civilization. Thus the articles discovered in Switzerland give us the history of the state of industry in ancient Helvetia, and those which came from abroad furnish us with an idea of the development peculiar to other lands than our own. Certain of those articles are all the more precious because they belong to an age anterior to the earliest written documents, and allow us, in the absence of these, to reconstruct the history of the early ages of humanity, just as geology enables us to retrace the history of our globe by the study of its strata and its fossils.

The ethnological collection includes the productions of the industry of modern tribes who, as yet, are strangers to European civilization. It is very closely connected with antiquities because, equally with them, it tells us the story of the various degrees of development through which men pass ere they attain to civilization properly so called. We may safely affirm that the various degrees of present human development characterize the successive phases of that development in antiquity. It is easy to appreciate the civilization of a people according to the character of mineral materials used in its industry; and there is a long series to pass through from the savage who supplies the want of metals by the use of stone and bone to the people who use the most various materials. Placing ourselves at that point of view, we perceive that the greater the use of the metals, and especially of iron, among a people, the greater is their industrial development. The application of these observations to antiquity is fertile in unforeseen results. The articles discovered being classed according to the materials employed and the manner of working them up will furnish us with series which, taken in the same country, will indicate the successive phases of that country's civilization. We shall find one age in which, just as among the savages, stone supplied the place of the metals. In another age, copper, tin, gold, and a little silver will be employed for ornaments and for various instruments, as among the Mexicans before the discovery of Columbus. In a third age iron will be superadded to the materials previously known and used, and it is then, and not until then, that we find writing is introduced and get the first historical data. The Helvetians had the arts of writing and of using iron in the time of Julius Cæsar, and our first historical traditions are no older, although, at that date, a great many generations had succeeded each other in our country.

These general considerations suffice to give an idea of the kind of interest possessed by antiquarian and ethnological collections which are, as it were, a picture of human progress, studied in one case in the series of successive ages, in the other in the series of contemporary nations. Let us now see how far our collections exhibit this double series.

I. SWISS ANTIQUITIES.

A. The Stone Age.—The name of the stone age is given to the ante-historical period during which the primitive inhabitants of the country were ignorant of the use of the metals, and employed instead of them stone, bone, and even wood. Switzerland was already inhabited during this early period. The museum possesses seven instruments of these rude times which were found in the canton of Vaud, and some *fac-similes* of similar articles from the country are in various hands. The specimens preserved are exceedingly interesting. If their number is very limited, we must bear in mind how far from extensive have been discoveries of the kind in this canton.

B. Age of Bronze.—This age takes its name from the metal used, in the absence of iron, for cutting instruments, and also for various ornaments. The bronze of that period is an alloy of from 10 to 15 parts of tin to from 85 to 90 parts of copper. The tin being brought from England, indicates a certain progress in commerce. The greater part of the copper also must have been imported into our country; which, however, as is proven by some discoveries, possessed founderies, and the art of alloying the metals.

The collection of antiquities includes fifty-eight articles in the bronze of that period, among which are two swords and two daggers complete, three javelin or lance heads, and several *celts*, (a sort of hatchets and chisels,) two sickles, bracelets, brassards, or *arm-pieces* of armor, and a great number of hair-pins. Most of these articles were found in tombs, others in open ground, and some, of which M. F. Forel is the donor, amidst the wreck of the lacustrian habitations of Morges.

C. First Age of Iron—*Helvetian period.*—The study of the progress of industry in the country and of the various modes of sepulture has enabled me to distinguish a certain number of tombs and of antiquities which characterize the Helvetian period prior to the Roman domination. It appears, from various observations, that the Helvetians were not the earliest inhabitants of our country. They subjugated a more ancient population, and brought with them the knowledge of iron, which is found in most of their tombs. We also find in their burial places Gallic coins, of from four to two centuries earlier than our era. The Helvetian antiquities are not distinguished solely by the introduction of a new metal; the materials which had previously been used are employed with a new art; new forms and new ornamentation appear. Colored or enamelled glass is used for bracelets, formed of a single ring, and for necklace beads. It will not be deemed irrelevant to add, upon this point, that Pliny the elder, as early as his day, attributed to the Gauls great skill in glass-work.

The museum possesses only seven articles belonging to this third age, namely, two bronze rings, one necklace of beads of glass and amber, two glass bracelets, one lignite bracelet, and a disc, in bronze,

formed of concentric circles. The use made of this last article it is difficult to conjecture.

D. SECOND AGE OF IRON—*Helvetic-Roman period.*—For a long time Roman antiquities monopolized the general attention, and accordingly the museum contains about two hundred and fifty articles of that kind, not including a few fragments of but little value. Iron is employed for axes, arrow-heads, keys, horseshoes, sickles, nails, and various other things; but it is remarkable how rare it is to find the sword of the conquering people, which is wanting in most collections of Roman antiquities.

The museum contains twenty-two statuettes in bronze, some of which are specimens of admirable ancient art. Among them I may mention a Gaulish Jupiter, a Mercury, and a small goat, found at Ursins. As very precious objects, I would also cite the great lamp in bronze, from Nyon; the *taurobole*, (sacrifice of the bull,) from Vidy; a bronze medallion, and an Etruscan mirror, found in the ruins of Aventicum. There are also several clasps or buckles, in bronze and in silver gilt, which are not without interest; also a series of bracelets, found at Bière, characterize Helvetian art under the dominion of Rome. The red earthenware articles are but few, and but little remarkable. With the exception of a few fragments, I need only mention the vase found at Fraidaigues, the reliefs of which have a stag hunt for their subject. Some plain pottery articles are well preserved. Three funeral urns, six large amphoræ, a number of weights, tiles, and pipes for the baths, complete our collection of Roman pottery. As objects of domestic use, the museum contains some household utensils in bronze, and a dozen of grinding stones for hand-mills.

The Roman marbles have been somewhat more increased this year, but even now they but very imperfectly represent the number and the beauty of the decorations of the buildings of that period. As objects of art I have little to cite beyond a small torso from Avenches, a mutilated head of St. Saphorin, a few sculptured fragments of elegant capitals, and a fragment of a sun-dial supported by an eagle rising into flight, a cornice placed in the choir of the cathedral, and a cylindrical vase from the neighborhood of Nyon. To the marbles are attached the Roman inscription, which words are seven in number, and are completed by fac-similes disposed in tapestry. The mosaics consist of a table and some slabs from a pavement at Orbe, presented by M. de Bonstetten. The mosaic from Bangy can be removed from the workshop of M. Doret when the marble room is ready, and that will also be the time for taking up the pavement from Vullierens, deposited in the academy, as well as the mosaic from Yvouand, which I hope can soon be removed.

E. *Helvetic-Burgundian period, (from the 5th to the 9th period.)*—The objects of this new period, to the number of 140, come almost exclusively from sepultures, and are connected with the industry which characterizes the origin of modern civilization. The most remarkable portion consists of fifteen damascened clasps, and nine clasps with

Christian symbols. These last have taken their place in science, revealing, as they do, the commencement of Christian art, and a symbolism especially peculiar to our country. A gold buckle, set with red glass, reminds us of the importation of an oriental art. A small balance, found, together with a sword, in a tomb at Severi, indicates that the person buried there had been a judge. Necklace-beads present curious resemblances to the most ancient art of the Phœnicians, whose productions were found in the ancient tombs of Egypt as well as in those of most European countries from the Crimea to the shores of England. The arms consist chiefly of cutlasses, some lance heads, and two axes. We may also mention four clay vases and four in stone, worked by means of the turning wheel. Finally, the epitaph of the young Laudoalda belongs to the end of that period.

If we look at those objects, in connexion with their prototypes, we shall see reason to be surprised at finding how few models have been borrowed from Roman art, while most of them are found either in the Gallic antiquities of the first iron age, or in those of Siberia, preserved at St. Petersburg.

F. Middle Age.—Only fifty articles belong to the middle age. The most ancient, and perhaps the most precious, is a small reliquary of sculptured ivory with silver leaves. That article was found in a tomb in the court of the castle of Lausanne, and is connected with the ancient establishment of St. Maire. Some church vases, in brass, bear inscriptions, of which only one is clearly legible—Wart geluck all Zeit, *be always happy*. These vases were much used during the twelfth century; they are found precisely the same from Syracuse to Drontheim. A great number were made at Lubeck; and in the north of Germany I have seen some still employed upon the baptismal fonts. A small stained glass circular window presents a subject of national interest, the grue, (crane,) of Gruyere. I must further mention keys; spoons; four seals, in bronze; a cutlass; a dagger; a lance head, in iron; knightly spurs; horseshoes; halberds; a crossbow, and some statuettes, in bronze, of the time of the Renaissance. A capital, ornamented with a curious sculpture, found at Maladeire, near Montreux, may take its place in the marble room with some fragments of the architecture of the middle age, found behind the castle of Lausanne.

G. Ancient Fire-arms.—A few specimens of fire-arms have been placed in the museum, which may some day form a portion of an armory room. The two pieces of the greatest national interest are a cannon and a mortar, in iron, relics of the great battle of Grandsau. They were presented by Lucien Valotton, of Vallerbes. Six muskets, or fusils, are more or less ornamented; some swords belong to the latter centuries. Two cartridge-boxes with the crane are, no doubt, of a time posterior to the counts of Gruyere.

One of the ornaments of the armory which is yet to be created will, undoubtedly, be the articles connected with the first Napoleon, the gift of M. Noverraz, viz: three saddles, in velvet and gold lace; three bridles, plated with silver; three snaffles; four fusils; the key

of Napoleon's house at Longwood; a map of Switzerland, with strategic annotations; a volume of the Imperial Almanac for the year 1807, and a certain number of medals relating to Napoleon I.

II. FOREIGN ANTIQUITIES.

A. Egypt.—Thanks to the generosity of our compatriots, the museum of Lausanne possesses some specimens of Egyptian antiquities. Those articles, it is true, are far from numerous, still they suffice to give some idea of that kind of art, and it is to be hoped that, in the course of time, we shall have, if not an Egyptian museum, at least articles sufficiently numerous to give a better idea of the age of the Pharaohs.

Two mummies, well preserved, occupy a separate case. The Egyptian skeleton has been completely set up, but for the present it has been left in the glass-fronted case of the botanic hall, where also is a handsome wooden sarcophagus in which the bones composing this skeleton were found. We have, also, two mummies of children, a small crocodile, some statuettes and amulets in vitreous clay, four statuettes in bronze, four in wood, some stuffs, and a wooden tablet covered with hieroglyphics.

B. Albano.—Seven vases, the gift of the Countess de Rumine, were found in a bed of peperin, situated between Albano and Marino, to the southward of Rome. At that point the most ancient pottery of Italy is found.

C. Greece.—The ancient art of Greece is represented only by seven vases, found in the vicinity of Athens, and given by Dr. Auguste Chavannes. Their interest consists chiefly in their showing that the art of the potter proper to Magna Grecia was not unknown to Greece, properly so called, a question a long time doubtful, but completely decided by various discoveries.

D. Magna Grecia.—Thirteen vases, six of which are added to her other generous contributions by the Countess de Rumine, are more or less ornamented with the paintings to which the Egyptians have given their name, pictures representing subjects of history, mythology, or common life. Notwithstanding the small number of these vases they suffice to give us an idea of the development of that kind of art in Magna Grecia.

E. Roman Antiquities of Italy.—Some slight fragments of marble or stucco, which travellers have brought from different parts of Italy, scarcely deserve mention. But that can by no means be said of some objects found at Rome and presented to the museum by M. the Consul Begré. They consist of coarse potteries and some articles in bone, such as punches and dice for gaming.

These various articles are about fifty in number. Our own country possesses enough of Roman fragments to make it worth our while

industriously to search for them, which would in nowise prevent us from receiving with gratitude the gifts sent to us from other countries.

The collection of antiquities numbers about seven hundred objects. Of that number one hundred are foreign to Switzerland; most of the others have been found in the canton of Vaud, and seventy-two belong to a time anterior to the Roman domination in Helvetia. Although this collection is not very large, it yet possesses many articles well worthy the attention of antiquaries.

ETHNOLOGICAL COLLECTION.

This collection is devoted to the exhibition of the products of modern industry among peoples strangers to civilization, properly so called. The interest which belongs to this species of study consists not so much in the forms, more or less original, of arms, utensils, and ornaments, as in the diversity in the degrees of contemporaneous development, and in the connexion of the series with that of the successive phases of civilization through past centuries. The productions of people who at the present day are without knowledge of the metals enable us to form a more complete idea of the progress made in bygone ages by an industry which was equally without the metals. On the other hand, the analogy of the forms and processes employed in ancient and modern times shows us that the savage state is in reality only the extension of the age of stone, but it is important to prove that every stationary state is a state of degradation. And accordingly the lacustrian peoples, even in the most remote antiquity, differed in very many respects from the existing savage. We see among the earliest population of Europe the same lack of materials, but even in their early age that population progressively developed its industry. One of the chief causes of the stationary state is the immobility of ideas arising from the want of communication which constitutes the isolation that is always hostile to progess. Isolation had the same effect upon the first emigrants into the west as upon the savages of our own time, but with this difference, that with the former the conditions of existence changed, while with the latter they remained the unchanged and the insurmountable barriers to progress. Like causes produce like effects, and we may affirm in general terms that man placed under analogous conditions of existence acts in an analogous manner, independently of both time and place. For this reason the study of the various degrees of contemporaneous industry serves to throw new light upon that of anterior ages. The astonishing variety of industrial products, in ancient as well as in modern times, proceeds from general laws, the application of which, in substance the same, proves in a very striking manner the unity of the human mind.

Our collections are, doubtless, very insufficient to justify these observations to their full extent, but it is to this result that they must tend if they are to have a really scientific value.

It will suffice to indicate, according to the places of their origin, the objects collected in the museum, to note some of those resem-

blances, and to have an idea of the nature of a certain number of articles which must have been made and used by the primitive people of our own countries, but which the destroying action of long ages has prevented from coming down to us.

A. North America.—Thirteen arrow heads of flint, found upon the banks of the Ohio, and precisely like those of Europe in the age of stone.

Arrows, with their shafts.

Two pipes, one of them from Canada.

A saddle, in cloth.

Moccasins and a cap.

A basket of the Esquimaux of the coast of Labrador.

B. Antilles.—A fan from the island of Cuba.

Five arrows entirely of wood, from the island of St. Croix.

C. South America.—The hammock, or cot, of a Brazilian chief. It is composed of stuff and decorated with garlands of feathers.

D. Society islands.—Stuffs in bark and Otaheitan paper.

E. Friendly islands.—A fly-flap; a club of carved wood; a basket.

F. New Caledonia.—A club of carved wood; two scalping instruments, one of stone, the other of hard wood; a bag for sling-stones.

G. East Indies—Asia.—Six arrows, with iron heads.

A sagaye, (African assagai,) a kind of spear for either thrusting with the hand or hurling from it.

A sandal wood necklace, from Bengal.

H. China.—A large parasol and shoes.

I. Senegal—Africa.—A bow and a quiver containing fifty arrows, with iron points or heads.

K. Articles from countries unmentioned.—Two aprons to conceal the nakedness of women; two fans; stuffs; a purse; seven woven baskets; seven vases, made of calabashes; an oar; two slings; a bow; several arrows; four casse têtes, or tomahawks; and two hatchets, in serpentine, which give an idea of the manner in which this instrument was furnished with its handle in the olden time.

OBSERVATIONS.

The foregoing details will show that the collections of antiquities and ethnology are not without considerable value, although there are some very important blanks yet to be filled up.

It is especially our duty to complete the national antiquities, which, as regards Switzerland, may supply the lack of written documents. When the pecuniary resources of a country do not allow of its procuring the beautiful productions of ancient art, that country should at least, to the fullest extent, avail itself of the resources which it can command. Had the State consented to examine by means of the dredge, or, still better, by means of the diving-bell, some of the lacustrian sites, which are so numerous on our shores, there would, undoubtedly, have been recovered very many objects which are imbedded in the mud and slime of our lakes, and, from one or more points, we should have recovered relics of the age of stone, which at present is represented by only a very small number of specimens.

If our collections are really and considerably to be extended, researches should also be made at points where we find burial places or ruins, which hitherto have been but superficially examined; but I am well aware of the difficulties which present themselves to this class of researches.

As relates to foreign antiquities, of which we already possess some specimens, opportunities occasionally present themselves for purchasing, at a moderate price, articles which, though of not the very first importance, would serve to complete series. As relates to this, we should offer proper inducements to our compatriots abroad to come to our aid.

I will suggest two other methods which, beyond all doubt, would contribute to the increase of our collections. The first would be to open rooms for systematic exhibition, so that the intelligent public should be not only interested but instructed. It is especially necessary that the cabinet of antiquities, *too often a mere sealed book*, should be more freely thrown open, and not kept, as it is now, more frequently closed than the other collections. More than once I have heard, from both compatriots and learned foreigners, complaints of the close of the cabinet of antiquities, even when the other departments of the museum have been open. No doubt the difficulty arises from the lack of a sufficient surveillance over all the rooms when open, a point upon which great improvement is very much needed. That surveillance could be maintained on open days by two or three gendarmes, who might be taken either from the military post or from the town sergeants, under the authority of the municipality of Lausanne.

Finally, if we would induce donations, we must not only exhibit our treasures properly, and make them to the utmost extent accessible, but we must impress upon the public the true end proposed in forming national collections. There are various means by which this object may be secured. We may insert in the public journals reports both more frequent and in greater detail, or we may publish a small and popularly written work on the present condition and contents of the museum, which work would be greatly aided and facilitated by the reports which are required from the conservators of the cantonal collections. The better and the more

widely to make known both what we possess and what we stand in need of, a certain number of copies of the suggested work might be distributed in the country; and it would not be amiss to send, also, some copies to those of our compatriots abroad who are in a position to aid us. The interest which the Swiss everywhere take in all that concerns their fatherland is too well known to allow of any doubt that such an appeal would be properly answered.

SUMMARY OF SUGGESTIONS SUBMITTED FOR THE CONSIDERATION OF THE COMMISSION OF THE MUSEUMS.

1. To undertake researches with the dredge, or, still better, with the diving-bell, upon the sites of lacustrian habitations.
2. To grant an allowance to some of our compatriots abroad to enable them to collect antiquities or ethnological objects in Italy, the Indies, Australia, and America.
3. To hasten the completion of the repairs of the marble room.
4. To open the cabinet of antiquities as often as that of the other rooms of the museum.
5. To have gendarmes or civic police in attendance on the open days.
6. To publish a popular work on the object and present state of the museum.

REPORT TO THE COMMISSIONERS OF THE MUSEUMS OF THE CANTON OF VAUD,

ON THE

RESEARCHES MADE AT CONCISE,

FROM SEPTEMBER 23 TO OCTOBER 19, 1861.

BY FRED. TROYON.

THE proceeds of the public exhibitions at Lausanne, in the year 1859, for the benefit of the cantonal collections, allowed a sum of six hundred francs to be devoted to the acquisition of antiquities for the museum. The allotment of that sum enabled me, in the same year, to make researches, the result of which is described in my work on Lacustrian Habitations, pages 132, 139. Shortly afterward the remainder of the money devoted to the museum of antiquities was absorbed by the purchase of a great number of specimens discovered during the construction of the railway at Concise; but that advance having been repaid to me by the state, it has served as current funds until quite lately, when further expenses for new researches put an end to our resources.

Among the numerous places of exploration Concise was especially fitted for our researches by its high antiquity and the great number

of relics which it had previously afforded. There was yet another consideration to recommend it had any such been required. The fabrication of counterfeits invited by the great prices obtained by the railway laborers for the antiquities which they found at Concise, had caused much doubt alike as to the authenticity of many articles, and even as to the scientific value of the discovery. Those counterfeits, distributed in great numbers, are the more to be regretted, because the lacustrian site of Concise presents specimens of a peculiar industry, among which working tools of wood and stags' horn occupy an important place. In spite, however, of the existence of these numerous counterfeits, it is possible to distinguish the authentic types; but this being a business of appreciation it is not to be wondered at that opinions differed very much in regard to it. It was important therefore to undertake new researches at Concise and to adopt all possible precautions against counterfeits, so as to restore this locality to the place that it deserves to hold in the history of the discovery of lacustrian antiquities.

One of the best means for working with but limited resources, in sites covered with water, is the employment of the dredge or drag, which I have already described in my report to the commission of the museums of the 27th of December, 1858, of which subsequent experience has established the utility. Professor Gay, vice-president of your commission, and M. Bridel, engineer at Yverdon, have had an armed drag constructed which perfectly answers our purpose. The directors of the West Switzerland Railway Company on their part very kindly placed at our disposal a raft and the other things needful for our enterprise. Three laborers were sufficient to work our drag, which they did under the inspection of a person charged with that duty, and enjoined to place the produce of every haul into a chest furnished with a padlock. Two theological students in succession exercised this surveillance of the laborers, M. Alexis de Loës and M. Auguste Buttin, both of whom deserve our thanks for the conscientious manner in which they performed their fatiguing task. M. de Loës having during the first fortnight superintended the works with much zeal, was, at the end of that time, succeeded by M. Buttin, who, with like zeal, superintended during the next fortnight. I, also, went several times to Concise to inspect the works and to make various observations. The dredging continued from the 23d of September to the 19th of October, but bad weather limited the actual working time to nineteen days. The care and precautions bestowed upon these researches left no room for the slightest doubt as to the authenticity of the articles obtained from the dredge.

The lacustrian deposit of Concise, notwithstanding the considerable amount of detritus removed by the steam dredge in 1859, is still very far from being exhausted. It forms a submerged hill or mound of four hundred and sixty feet in length by two hundred and fifty feet in breadth, its greatest diameter being almost parallel to the railway. The bed of materials accumulated above the primitive bottom of the lake is about four feet, consisting of mud, sand, gravel, and stones, varying in diameter from a few inches to one or two feet, and con-

tains in its whole depth relics of ancient industry, so that its formation corresponds with the duration of the village or hamlet which existed at that point. A stone hatchet has even been found among the flints on the surface of the ground, and it was covered with a thick layer of soft, sandy stone upon the face that was in contact with the water, whence it follows that this little hill has not been increased in height since it has ceased to be inhabited by man. It is possible that the stones and gravel were at various periods deposited by the inhabitants of the village or hamlet with a view to consolidating the piles. However that may have been, it is amidst those deposits that innumerable remains of past industry may be found.

Pieces of wood and planks, carbonized more or less completely, have been drawn out of the depths of the artificial bed, and seem to indicate that on more than one occasion fire has wholly or partially destroyed the lacustrian dwellings of Concise. Upon some spots, decomposed branches form thick beds which contain various grains and different utensils; on others, the mud has especially accumulated; but in a general way, flints, many of which have been broken by the hand, are scattered over the whole site.

The piles which supported the cabins of this ancient hamlet have been shortened by the destroying action of the waves to the surface of the mound, while their lower extremity, deeply sunken in the earth, remains very perfect. Many of them penetrate but a little into the primitive bottom of the lake, and it is not uncommon to see the very notches made by the stone axes still remaining. The diameter of the piles varies from three to nine inches, and some of them consisted of pieces of wood cleft by the aid of the wedge. The principal kinds of timber employed were fir, birch, and especially oak. More than seven hundred and fifty objects bearing the marks of human industry were obtained by our latest researches, not reckoning innumerable bones of animals, most of which have been broken with the hammer.

The most remarkable and also the rarest articles are instruments which are still furnished with their handles. Of these I shall first mention an axe of the material called serpentine. It is fixed to a handle of buckhorn, the square extremity of which, opposite to the stone, entered the lateral mortise of a handle of fir wood. The three pieces, *i. e.*, the stone axe and the handle pieces, respectively of fir and buckhorn, were brought up together by the drag, and quite evidently all belonged to and formed one instrument. Although the wood is broken at the mortise, the manner in which the three pieces were formed into the one working tool is perfectly obvious. But it is probable that the adjustment was consolidated and strengthened by ligatures like those which I copied in my work upon the lacustrian habitations of ancient and modern times.

Three other fragments of axe handles show that their greatest dimensions corresponded with the cutting edge of the instrument, so that the strokes should be more certain, while the part adapted to the hand was slighter and lighter. Of those implements the whole length is scarcely a foot. Another axe, of serpentine, is still connected with its buckhorn handle of the same form as the preceding.

Two small axes of the same material are fixed to bifurcated handles. Five chisels of stone, still connected with buckhorn handles, present some varieties of form. Two of them, very like modern instruments of the same kind, have a blade of only five or six lines in width and a total length of from thirty-seven lines to five inches. The other two are shorter and wider, having at the end of the handle furthest from the blade a cylindrical bit of wood, the evident use of which had been to allow the hammer to be used without injury to the buckhorn. Two handles of this last kind preserve each a stone, the edge of which in a very decided segment of a circle can scarcely have served but as a mere knife for cutting through slight or soft articles. The imperfection of these rudely contrived tools might make one doubt their antiquity were not the circumstances under which they were discovered an abundant guarantee on that head. It is to be remarked that many of the stones which are still furnished with their handles penetrate but a little way into the buckhorn, and are readily taken out of the kind of socket which holds them. But as that slightness of adherence essentially results from the action of time, it is not an absolute characteristic of authenticity, for six of the pieces described above still preserve so great a strength of cohesion that the stones cannot be removed but with great effort.

Some of the buckhorns are armed with *punches* of *vegetable* material, the conical form of which is very greatly altered by desiccation. An axe handle is traversed lengthwise by a piece of wood broken at its thicker extremity and terminating in a point at the other. A cylinder twelve lines high by an inch in diameter and another buckhorn of egg shape serve as handles to wooden punches or bodkins. Two of these punches or bodkins and eight handles of this latter kind were also found, three of the latter being in an unfinished state.

Out of six buckhorn hammers, pierced transversely with a square or oval aperture, five have still attached to them the remains of their fir wood handles. Two of those hammers have at one of their extremities a cavity, in which we suppose a stone was sometimes fastened; and it is very possible that in some cases this was even sharpened into an axe.

Eight arrow points *in bone*, very like punches, bear traces of a blackish mastic and of fine ligatures. One of these has still attached to it a small fragment of its shaft, and shows, at the point of fracture of the mastic, a line of very small holes, formerly filled with the ligatures that bound the two pieces together. Among the relics in bone which must have been similarly used is a fragment of the inner bone, or tibia, of a leg, the cavity once filled by the marrow serving for the shaft-socket. Numerous staghorns have been used as handles. Six end pieces of antlers have at their thicker extremity a hollow which imitates the form of the stone article used as a cutting knife. One antler bears the impress of a flat instrument which had penetrated two inches deep into the handle; and in another similar article the cavity gives the form of the punch; finally, the cavity of one of these crooked handles resembles the socket of an incisor tooth of a rumi-

nating animal. Though we cannot precisely decide as to what instruments fitted into these antlers or parts of antlers, it is, however, quite certain that they served as handles for tools of various forms. Ten buckhorn handles, four inches in average length, and cut at both ends, have those cylindrical or conical cavities which, according to the objects discovered, may have held either punches or poignards. Some others of various forms, like a raven's beak, or curved naturally, also bear positive marks of having been used as handles. Sixty pieces, having the form of the foregoing, but without the hollow imprint of instruments, must be looked upon as unfinished articles kept in reserve for daily-occurring emergencies, according to a custom still observed by the inhabitants of that neighborhood.

Of fifty-one handles intended to receive stone chisels, twenty are perfect, sixteen have been formerly broken, and fifteen were never finished.

The buckhorn, which plays so considerable a part in the discoveries at Concise, has been especially used for *axe handles.* The last research there brought to light above two hundred, including sixty fragments, some of which, to be sure, may have belonged to the same article. Of that number, sixty-two are perfect, and forty-eight, not reckoning the small fragments, have been more or less so injured as to be useless. These handles are of three different forms. The great majority of them are made with pieces of buckhorn of an almost cylindrical shape, those of the second kind have on one side a prominence which serve as a rest for the hand, and the others, only eight in number, are bifurcated in facets on the part which enters into the handle in such wise as to enable the adjustment to be strengthened by means of a wedge. Twenty antlers, some of which have served as handles, are worn at the point into the form of chisels. Several pieces, also, have been cut into the form of elongated wedges.

A buckhorn and four canons or tibia sawed or split lengthwise, sharpened to very keen points may have served as weapons of war or as instruments of peaceful use. One hundred and one *bone punches* of from one inch to four inches in length, have rounded, oval, or square points. Four show the wear produced by the thread round the punch; six were arranged in the mud brought up by the dredge in the form of the teeth in a comb, but there was no trace of ligature which would warrant the assertion that that arrangement was not merely accidental. Thirty of the punches were made from the rib bones of different animals, and forty exhibited, on the end opposite to the point, a roughness which would have hurt the hand had not the instrument been inserted into a handle. The small dimensions, also, of some of them would have made it almost impossible to use them without handles. The same remark applies to the *bone chisels*, some of which are pointed at both ends; their length varies from one inch to five inches, and their cutting edge or point is from a line to eight lines in breadth. The chisels discovered during the last dredging were forty-six in number. Four teeth of the wild boar are sharpened into the form of a knife, or a miniature bill-hook.

Bone and buckhorn were also used in the manufacture of a variety

of ornaments. A pin, in the shape of a Roman T, is of remarkable fineness, taking into consideration the instruments used by the maker. The fragment of another article of the same kind has a cylindrical head. A crooked pin thirty-five lines in length exhibits less neatness of workmanship. Four pieces, clumsily cut into the form of tile-nails, are evidently unfinished. A small antler, only twenty-four lines long has been carved so as to imitate seven necklace beads placed one above the other, and diminishing from the base to the summit. Two bear's teeth, one having a hole pierced through it, and the other a groove around its roots, were suspended as ornaments or amulets, if we may judge from the subsequent custom. A fragment of a boar's tooth has also a hole pierced through it. Finally a small bead, of a whitish paste and two lines in diameter, testifies the love of even the most primitive people for personal ornaments.

At a period when the metals were unknown, stone held the first rank in manufacture, and the hatchet or axe was used for the most various purposes. Its dimensions, generally very small, varied from one inch to five inches in length, and from six to seventeen lines in breadth. But though this instrument sometimes supplied the place of the *chisel* and the *knife*, these two instruments are found in very clearly defined forms. Our dredgings have enriched the museum with a hundred and forty-five of those instruments, most of which are of opaque, or translucent serpentine. Of this number forty-eight are perfect or nearly so; fifty-eight useless from breakage or excessive wear; thirty-one were left unfinished or were broken while being cut; three present a very oblique blade. Some pieces are of remarkably fine finish, but others are equally coarse, and some mere splinters or fragments of stone have been simply sharpened on the edge so as to serve as knives or chisels. Among the unfinished pieces, one of serpentine was intended to receive an elegantly curved form; and five fragments of an instrument combining the axe and the hammer are of fine work, polished on their whole surface, and although broken at the cavity intended for the handle, they testify to an indisputable progress in the art of cutting and drilling stone. The various kinds of silex that have recently been discovered at Concise, whether opaque or translucent, and whether black, gray, brown, or of a milky white, are, for the most part, foreign to Switzerland, and probably came from France. Two pieces have been cut into arrow heads, one of them having the form of a lozenge. Five pieces are punches, which are quite perfect and may have served either as punches or as arrow heads; one of them is no less than sixty-four lines in length; twelve pieces, more or less fine, and with the edges cut into teeth, were intended to serve as saws, knives, and scrapers. A bone, having a longitudinal groove, was intended to receive one of these instruments; seventeen fragments of worked pieces, or of pieces detached by the hammer, complete, with a rock crystal, the series of this description of objects. I must add, however, that among the numerous flints which, in a proper state, lay scattered through the whole thickness of the artificial bed, there

were found numerous pieces of granite and quartzite, which have received the form of triangularly cut laminæ of silex.

Twelve stone discs, from thirteen lines to two inches in diameter, and from two to eight lines in thickness, have a funnel-shaped hollow on each side or face; the incomplete hollows on two of them enabled us to perceive the workman's mode of procedure. He commenced by cutting away the stone by gentle strokes of an angular instrument, working first on one side of the desc or plate, and then on the other, and when the two hollows met he finished the boring by turning a punch—of silex, no doubt—rapidly round and round, until he had smoothed away all the inequalities left by the first operation. The use of these plates or discs, of various kinds of rock, is doubtful as yet; they may have served as spindle whirls or as weights for a net. A small pebble, oval in form, and pierced on both sides so as to be suspended from a string, would seem rather to indicate the latter as their use.

It is probable that the hammer which served for cutting stone was a piece of flint from the shore, and that when it got broken its angular parts performed the part of the gimlets or awls. The last operation was performed with the aid of grindstones of soft freestone. Of these a great number have been discovered. Thirty of them have been put aside for the museum; all are worn in such a manner as to indicate the use that has been made of them, and many are sufficiently small to have been held in the hand, as our peasants use sharpening stones on their scythes. On one there is a concave and rounded groove, of two or three lines in width, reminding one of the grindstones in the north, on which they sharpen gouges.

Three heavy stones, with concave surface, have served as millstones, between which grain was ground. Though as yet only a very small number of seeds of wheat have been found at Concise, we know that it was cultivated in Switzerland in the stone age, and that in some parts quite abundant stores of it have been found. Raspberry seeds, wild plums, and especially nuts, are by no means rare among the specimens of Concise. Some seeds still remain to be decided upon.

The articles of *pottery* are, in general, very much damaged. According to the fragments that have been collected, the predominant form was that of the cylinder; though the forms of the urn, the saucer, and the bowl have also been discovered. Some specimens have prominences on the upper edge to enable the vessel to be held; in other cases there are holes through which a cord could be passed to serve as a handle. The coarse clay was kneaded with silicious flints, and shaped with the hand; the thickness of the sides is frequently from four to five lines. Some slender fragments of a much finer grayish clay, or covered with a black glazing, and ornamented with grooves or zig-zag lines, show that it is not always easy to distinguish between the pottery of the first age and that of later periods. The vases which were used for other domestic purposes served also for cooking, as is evidenced by the carbonized coating which still adheres to the inside of some of them.

It is interesting to find some *wooden articles* which give an idea of what the industry of the stone age could produce with the imperfect instruments which were at its disposal. The wooden handles, already spoken of, exhibited at the moment of their discovery—that is to say, before they were dried—a surprising finish. Two handles, terminating in a wide knob, were not without some taste. A cup or drinking vase of yew wood, about fifteen lines in depth, four inches in length, and twenty-two lines wide, has been cut with great delicacy. One especially interesting article is a fragment of plank, fifteen lines thick, eleven inches long, and between four and five inches wide. On one of its sides three grooves are cut in the form of a swallow tail, at a distance of between four and five inches from each other; the central one, two inches wide and six lines deep, still retains one of the pegs, intended to join this plank to another. That sort of junction exactly resembles a practice of our own day in some country houses; but this fragment seems to be more likely to have formed part of a door of a cabin, unless, indeed, wooden buildings on our lakes were unknown at so early a period. At the north we have indications of them from the most distant periods; only it is probable that they fastened the planks together otherwise than by pegs. This piece, carbonized on both sides and on one of its ends, is a relic of the fire. Another fragment, with swallow-tail grooves, also came from the midst of the bed of gravel, as did all the pieces of other plank which bear marks of fire. These planks could scarcely have been procured excepting by splitting the trunk of a tree by means of wedges; the stone axe smoothed away the inequalities, and the chisel served to hollow out the grooves. The junction of those pieces by means of pegs, proves that the art of building was carried much further by the lacustrian populations than we should infer from a mere inspection of their working tools. It is not easy to say what was the purpose of a plank pierced with a square and oblique hole. A piece of wood three inches wide was hollowed out into the form of a pipe or gutter to convey water from a roof, but in drying it lost the form which it had when taken out of the water. Various fragments appear to have been oars, clubs, and other instruments. Some are cut into the form of punches; others, which are in that of wedges, have probably been rounded by rolling in the water; a great number were buried at the same spot amidst the piles. These, as I have already mentioned, show the notches made by the stone axe. Even a large mushroom was brought up from amidst the sands. In the fear that I might not be able to keep sufficiently intact some of the specimens, in spite of the means I employed, I had copies of them made in plaster, which exactly represent their forms before they were altered by drying.

The drag or dredge recovered from the middle of the artificial bed of Concise a considerable number of *teeth* and *bones* of animals, of which I may first mention the vertebra of a fish and a piece of rough epidermis, of what creature I cannot as yet say. Some staghorns are of considerable size, and many of them bear the imprints of the

teeth of some gnawing parasite. Other horns are those of the elk and the roebuck.

We find the bear, the boar, the beaver, and a number of jaws of small species of gnawing and carnivorous animals. The horse seems to be as yet rare, the ox is abundant, the goat, the sheep, the domestic swine, and the dog complete the list of domestic animals. This list, still incomplete, can give no adequate idea of the numerous bones discovered; their aggregate weight reaches to many hundred pounds. They are in general very much broken, which may result either from the fabrication of instruments or from the decided taste of the lacustrian population for marrow. Professer Rutimeyer will be good enough to pass judgment upon this rich collection of bones, and while awaiting the results which he will communicate to us I copy from that learned naturalist his list of the animals, the bones of which, preserved in the museum of Lausanne, had been previously obtained from the site of Concise. They are the primitive ox races, *trochoceros* and *brachyceros*, the goat, the marsh hog, primitive races of the sheep and the dog, the stag, the elk, the goat, the bear, the boar, the wolf, the fox, the beaver, the badger, the pole cat, and the martin. The first vertebra of a human back bone must be mentioned, as well as some fragments of skulls which have passed into other hands. It is in the remarkable work that M. Rutimeyer has published upon the fauna of the period of the lacustral habitations in Switzerland that we must study the important scientific questions suggested by these determinations.

Notwithstanding the very numerous and various objects brought to light by our latest dredgings, it is a remarkable fact that not one article of metal was dredged from the bottom of the lake on these occasions. Yet in the labors of 1859 some bronze instruments were discovered; but it must be borne in mind that they were obtained from one of the extremities of the lake at which we had not time to place our drag. Everything tends to establish the belief that, after the destruction of the hamlet, a few cabins which escaped at the time of the fire, or which were subsequently built, were still in existence at the commencement of the following period. I say at the commencement, because during the second age new habitations were built further advanced in the water, where the bronze sword was found which is preserved in the museum of Neufchatel.

The various kinds of objects of industry which have been discovered at Concise were not distributed in the same abundance at all points of the site. The whitish and veined silexes come from the same point, and the two principal kinds of axe helves also come from two different parts of the site. The stone discs with a hole hollowed in them were almost all found in the same place. The spot which contained the most of uninjured objects was called by the laborers "the handle warehouse." Without attaching too much importance to those different species of deposits, it is yet not without interest to add that observations of the same kind have been made at some other sites of lacustrian habitations, which lead to the inference that there already

really did exist actual workshops. Starting from this point of view, we might admit that the workers in bronze occupied only one wing of the hamlet, but the extremely limited number of articles of metal previously found, compared with that of the instruments of stone and of bone, discovered in thousands, sufficiently shows that it was long before bronze was known, and that it was not generally used before the destruction of the old hamlet.

The aggregate of the specimens recently found at Concise shows to how great an extent bone and stag's horns were used in primitive industry. Independently of the serpentine axes fixed in buckhorn, stone knives and chisels also have their handles of this material. Wooden punches still adhere to their handles, and a bone arrow head still exhibits traces of the shaft. Numerous stag horns bear the hollow impress of the instruments of various forms to which they have served as handles. The authenticity of these pieces is a fact important to science. It is to be regretted that the advanced period of the season compelled the suspension of the dredgings earlier than was intended, but I hope that they may be resumed, for the repository of Concise has not yet given its last response.

In my last work I gave the historical results which appear to me to flow from the researches made in late years in the lakes of Switzerland. I shall not, therefore, endeavor to deduce from the preceding data all that results from them as to the industry and the mode of life of the primitive populations of our country, but I will just so far enter into particulars as to show the astonishing abundance of objects in the spot which we have examined.

The dredge, which was worked on this last examination during nineteen days, brought up from the lake at least seven hundred and fifty pieces bearing the impress of human industry, without counting innumerable bones of animals, which, after being carefully culled, covered the raft twice a day with rubbish to be thrown on the slope of the railway. In 1859 the steam-dredge, which worked twenty-five days, recovered from the lake at the same spot fifty raft loads a day. One of the two rafts which attended the steam-dredge was that which we employed, and, according to the statement of the laborers, the amount of rubbish sent to the railroad was at least double that which we obtained from the culling of the objects of industry. It may be added that the steam-dredge brought up antiquities from the beginning to the end of its working. It follows, then, that twelve hundred and fifty raft loads were taken from the same site in 1859, while we in our later dredgings took only thirty-eight, and admitting an average equality of riches of antiquities, the wrecks of industry discovered two years ago amounted to above twenty-four thousand pieces, which is not out of proportion to the sums of money realized by the railway laborers.

The comparatively small number of objects collected by our late dredgings includes articles which had not before been obtained from Concise; as, for instance, a portion of the wooden handles, the planks furnished with swallow-tail grooves, the yew-tree cup, the bone arrows, with traces of mastic, and the wooden punches

fixed in their handles. It is not to be wondered at that the first dredgings, which were thirty-two times larger, should have brought to light some objects of which we have not had the fortune to recover counterparts. I may mention, among others, the teeth fixed to stag's horn, of which M. Rossine, the engineer, got a specimen for the Cantonal Museum on the first day of the working of the steam-dredge, which was before the fabrication of the counterfeits.

Without laying too great stress upon the foregoing figures, they suffice to give a notion of the riches of this site, of its importance, and of the duration of its occupation, as well as of the variety of the types which it may still contain, for all the dredgings have not nearly exhausted the vast bed of the deposits of the antique hamlet of Concise.

ANCIENT MOUNDS AT ST. LOUIS, MISSOURI, IN 1819.

By T. R. PEALE,

CHIEF EXAMINER IN THE UNITED STATES PATENT OFFICE.

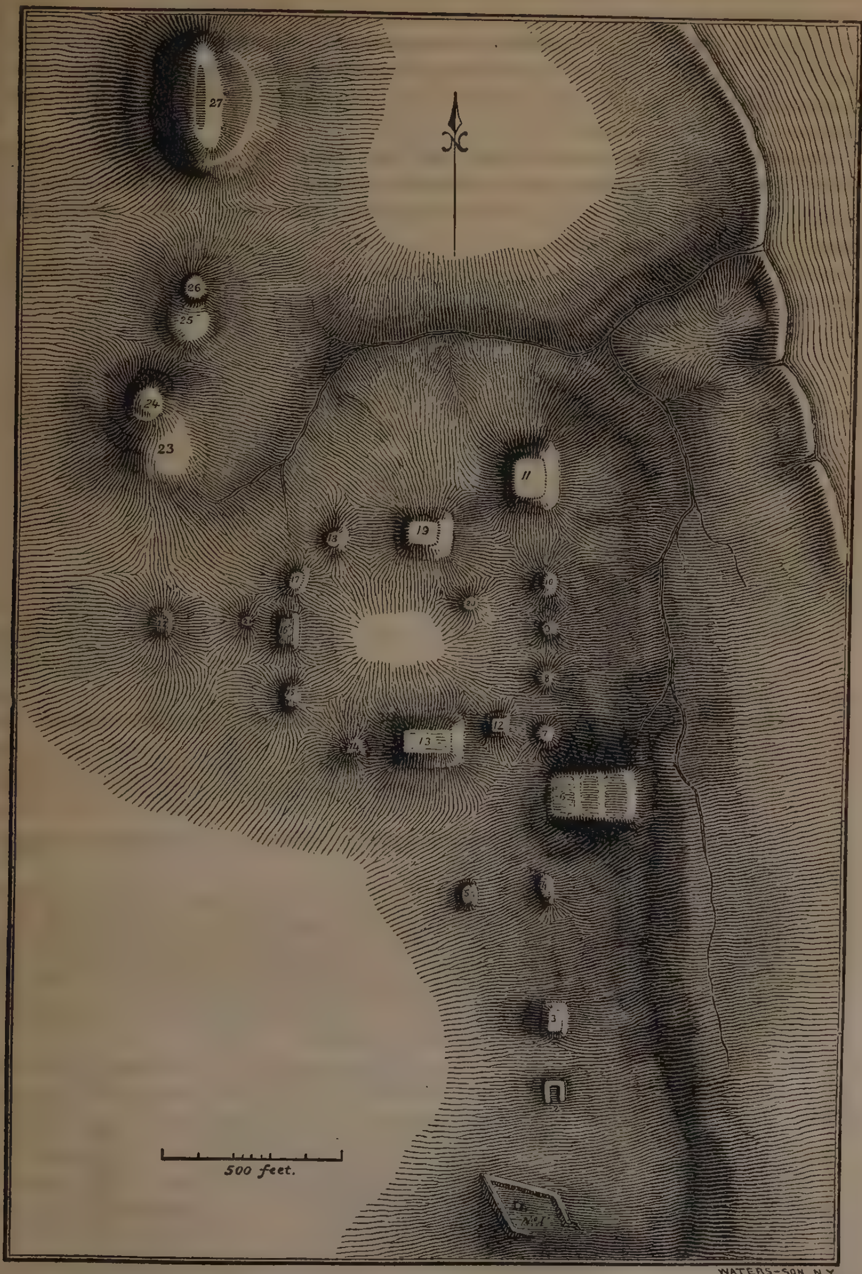
The contents of an old portfolio will sometimes restore a lost fact which may be useful when connected with the observations of the day. So I hope it may be with the accompanying map of a series of mounds as they existed about forty years since, in the vicinity of the city of St. Louis; these mounds, like all other vestiges of the aborigines of our country, must soon pass away. The map may fix a remembrance of one period of their existence, and it is for this purpose that it is offered to the Institution without further apology.

An exploring expedition, destined for the upper waters of the Missouri river and the Rocky mountains, was fitted out at Pittsburg, Pennsylvania, in the spring of 1819. It was placed in charge of Major (now Colonel) S. H. Long, of the United States topographical engineers, and was accompanied by a scientific corps, of which the writer of this article was the junior member.

For the use of the expedition a small steamboat was constructed on a plan supposed to be well adapted to the purpose, and named "Western Engineer." It was furnished with two propelling wheels placed in the stern, one of which bore in large letters the name of James Monroe, and the other that of John C. Calhoun. The President of the United States and the Secretary of War were thus represented as the propelling power of the expedition.

This little steamer, the first which ascended the Missouri, and perhaps the only one known to history as bearing three names, produced a great impression on the sons of the forest as they beheld it struggling against wind and currents, belching forth flame and smoke from

the head of a serpent on its bow, and awaking the echo by its loud and stentorian breathing.



While this expedition was stopping at St. Louis to repair the steamer, in June, 1819, the late Mr. Thomas Say, also one of the expedition, and myself made a survey of the ancient mounds then in

the vicinity of the city. An account of these mounds was published in 1823 in a note to the first volume of Long's Expedition, page 59, but without the map, which was omitted to give place to what was considered more important matter, and has remained unpublished until now. The survey, although not made with great precision, was sufficiently accurate to give a definite idea of the form and relative position of the mounds.

The following notes were made at the time and published by Mr. Say. The opinion of my much-respected friend concerning the objects of these earthworks, given in the extract, have since been corroborated by other observers:

"Tumuli and oth.r remains of the labors of nations of Indians that inhabited this region many ages since are remarkably numerous about St. Louis. Those tumuli immediately northward of the town and within a short distance of it are twenty-seven in number, of various forms and magnitudes, arranged nearly in a line from north to south. The common form is an oblong square, and they all stand on the second bank of the river. The statement given below of the forms, magnitudes, and relative position, is the result of actual admeasurement taken with care, and with as much accuracy as their present indefinite boundaries, together with the dense growth of underwood covering their surface, and tending to beguile and obstruct the vision of the observer, will admit. [A pocket compass and tape measure were the only instruments used.]

"It seems probable these piles of earth were raised as cemeteries, or they may have supported altars for religious ceremonies. We cannot conceive any useful purpose to which they can have been applicable in war, unless as elevated stations from which to observe the motions of an approaching enemy; but for this purpose a single mound would have been sufficient, and the place chosen would probably have been different.

"Nothing like a ditch or an embankment is to be seen about any part of these works.

"What we have called *base* in the following statement, is in reality the length of a line passing over the top of the mound from the termination of the base each side.

"The numbers refer to the map. The heights are estimated, with the exception of two."

No. 1 is the remains of what was reported to be the bastion of an old Spanish stockade, indications of a ditch being still visible.

No. 2. A square with a hollow way, gradually sloping to the top; or in other words, a hollow square, open behind.

Base	50	feet.
Height	5	"
Distance north from the Spanish bastion	259	"

No. 3. An oblong square.

Longitudinal base	114	"
Transverse base	50	"
Length at top (or flattened portion)	80	"
Perpendicular height	4	"
Distance from No. 2 north	115	"

No. 4. An oblong square.

Longitudinal base	84	"
(Flattened portion) top	45	"
Perpendicular height	4	"

No. 4. Distance north from No. 3 .... 251 feet.
Nos. 2, 3, and 4 are each about 33 ordinary paces from the edge of the second bank of the river.
No. 5. An oblong square; longitudinal base .... 81 "
Top .... 35 "
Perpendicular height .... 4 "
Distance west from No. 4 .... 155 "
No. 6. Different in form from the others. It is called the *Falling Garden*, and consists of three stages, all of equal length, and of the same parallelogramic form. The superior stage, like the five succeeding mounds, is bounded on the east by the edge of the second bank of the river. The second and third stages are in succession on the declivity of the bank, each being horizontal, and are connected with each other, and with the first, by an abruptly-oblique descent.
Longitudinal base .... 114 feet.
Top or flat portion .... 88 "
Transverse base of the first stage .... 30 "
height of the first stage .... 5 "
Declivity to the second stage .... 34 "
Transverse surface of the second stage .... 51 "
Declivity to the third stage .... 30 "
Transverse surface of third stage .... 87 "
Declivity to the natural slope (on the east) ... 19
No. 7. Like the three succeeding ones, conical.
Distance northward from No. 6 .... 95 "
Base .... 83 "
Top .... 34 "
Height .... 4½ "
No. 8. Distance about north from No. 7 .... 94 "
Base .... 98 "
Top .... 31 "
Height .... 5 "
No. 9. Distance about north from No. 8 .... 70 "
Base .... 114 "
Top .... 56 "
Height .... 16 "
No. 10. Distance about north .... 74 "
Base .... 91 "
Top .... 34 "
Height .... 8 or 10 "
No. 11. Nearly square, with a large area on the top; (a brick house is erected at the southwest corner.) The eastern side appears to range with the preceding mounds.
Distance .... 158 feet.
Base .... 179 "
Top .... 107 "
Height, west side, say .... 5 "
Height, south side .... 11 "
Height, east side .... 15 or 20 "

No. 12. Nearly square, westwardly, a little north from No. 7, and distant from it .... 30 feet.
Base .... 129 "
Top .... 50 "
Height .... 10 "

No. 13. A parallelogram placed transversely, with respect to the group.
Distance .... 30 feet.
Distance from No. 5 north 10 west .... 350 "
Longitudinal base .... 214 "
Top .... 134 "
Transverse base .... 188 "
Top .... 97 "
Height .... 12 "

No. 14. A convex mound, west .... 55 "
Base .... 95 "
Height .... 56 "

No. 15. Together with the succeeding ones, more or less square.
Distance northwest .... 117 feet.
Base .... 70 "
Height .... 4 "

No. 16. Distance north 10 east .... 103 "
Base .... 124 "

No. 17. Distance north .... 78 "
Base .... 82 "

No. 18. Distance north northeast .... 118 "
Base .... 77 "

The mounds from 14 to 18, inclusive, are so arranged as to form a curve, which, when continued, terminates at the larger mounds Nos. 15 and 19.

No. 19. A large quadrangular mound, placed transversely, and with No. 13, ranging in a line nearly parallel to the principal series, (from 2 to 11.)
Distance north northwest from No. 13 .... 484 feet.
Distance east northeast from No. 18 .... 70 "
Base .... 187 "
Top .... 68 "
Height (by measurement) .... 23 "

No. 20. A small barrow, perhaps two feet high, and of proportionably rather large base, say .... 15 or 20 feet.

No. 21. A mound similar to the preceding, same height, west of No. 16, base .... 25 feet.

No. 22. Quadrangular, distance west from No. 16 .... 319 "
Base .... 73 "

No. 23. A mound of considerable regularity, but owing to the thickness of the bushes we cannot at present satisfy ourselves of its being artificial, though from its corresponding with No. 25, we suppose it to be so.

No. 24. Appears to be an irregular mound ten or twelve feet high, and one hundred and forty-five feet base.

No. 25. Distant north 10 east one hundred and fourteen feet, and following this course one hundred and thirty-two feet we arrive at an elevation on its margin, as is also the case with No. 24, and which we have numbered 26.

No. 26. Of which the base is eighty-nine feet and height ten or twelve. It is distant W.NW. from No. 19,538 feet.

No. 27. Is the largest mound, of an elongated-oval form, with a large step on the eastern side, distance north from No. 26 .... 1,463 feet.*

Longitudinal base	319	"
Longitudinal top	136	"
Transverse base	158	"
Transverse top	11	"
Step transversely	79	"
Height by measurement	34	"

At the distance of a mile to the westward is said to be another large mound.

On the summit of No. 27 are found several graves. "We opened five of them, but in one only were we fortunate in finding anything interesting, and all that this contained was a solitary tooth of a species of rat, together with the vertebræ and ribs of a serpent of moderate size and in good preservation; but whether the animal had been buried by the natives, or had perished there after having found admittance through some hole, we could not determine." These graves are similar to many found on the hills in the neighboring country, and evidently contained the relics of a more modern people than those who erected the mounds. "They do not rise above the general surface, but their presence is ascertained by the vertical stones which enclose them and project a little at either end of the grave. When the included earth and the numerous horizontal flat stones are removed, we find the sides neatly constructed of long flat stones vertically implanted and adapted to each other, edge to edge, so as to form a continuous wall. The graves are usually three or four feet, though sometimes six feet in length."

The city has long since been extended over these mounds, and although the marks of the sites of some of the larger are still seen, all vestiges of the greater number have been obliterated.

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* The relative position of this mound could not be correctly given on the map without increasing the length to an inconvenient extent. Its true relative place would be considerably beyond the northern margin of the map.

INSTRUCTIONS

FOR

ARCHÆOLOGICAL INVESTIGATIONS IN THE U. STATES.

PREPARED FOR THE SMITHSONIAN INSTITUTION BY GEORGE GIBBS.

THE Smithsonian Institution being desirous of adding to its collections in archæology all such material as bears upon the physical type, the arts and manufactures of the original inhabitants of America, solicits the co-operation of officers of the army and navy, missionaries, superintendents, and agents of the Indian department, residents in the Indian country, and travellers to that end.

CRANIA.

Among the first of these desiderata is a full series of the skulls of American Indians.

The jealousy with which they guard the remains of their friends renders such a collection in most cases a difficult task, but there are others in which these objects can be procured without impropriety. Numerous tribes have become extinct, or have removed from their former seats; the victims of war are often left where they fall; and the bones of the friendless and of slaves are neglected. Where, without offence to the living, acquisitions of this kind can be made, they will be gladly received as an important contribution to our knowledge of the race.

Various methods of disposing of the dead have obtained among different tribes, as burning, burial, deposit in caves, in lodges, beneath piles of stone, and in wooden sepulchres erected above ground, placing on scaffolds or in canoes, and attaching to the trunks of trees. In many instances the bones, after a season, are collected together and brought into common cemeteries. Where the first mentioned form, that of burning, is followed, we must, of course, look to chance for the preservation of the remains. This method is, however, more rare than the others.

It is requisite, for the purpose of arriving at particular results, that the most positive determination be made of the nation or tribe to which a skull belongs. In extensive prairie countries, hunted over or traversed by various tribes, or where, as on the Pacific coast, several tribes and even stocks inhabit a district of limited extent, this is often difficult, or even impossible. Unless, therefore, information of a direct nature is obtained, the collector should be guarded in assigning absolute nationalty to his specimens. It will be better to state accurately the locality whence they are derived, and the owners or frequenters of the neighborhood, to one of which it is

likely to belong. Where several specimens are collected they should be numbered to correspond with a catalogue in which the above points are mentioned, as also whether they were found in a grave or other place of deposit, with its description, the character of the ornaments and utensils placed with it, and whether it was in its original place or had been assembled with others. Finally, it should be ascertained if the tomb be one of existing or recent inhabitants of the country, or of one more ancient and preceding, such, for example, as the mound builders of the Ohio, and, in this latter case, if the remains are those of the original inhabitant, or have been since deposited. In this the character of the articles buried with the body will often furnish a clue. The same precaution should be adopted where tribes have been removed to reservations not on their original ground. In short, where any doubt exists in the mind of the collector, all those circumstances should be examined into which, in the absence of direct testimouy, will facilitate a conclusion as to origin.

Among some nations, it may be mentioned in this connexion, it is the custom to marry out of the tribe as a matter of policy. Skulls of women found in the cemeteries of one of these would therefore very probably belong to an adjoining tribe, and it may happen of an entirely different stock. In such cases, too, there can be no certainty that the men themselves are of the pure blood of one race, and it is important to ascertain if this custom exists among those tribes where flattening or altering the head is common to *both* sexes; particular suspicion should attach to any having the skull unaltered. This process is usually a mark of rank, or at least of freedom, and the skull, if found in a burial place or well-marked receptacle, may almost be assumed to be that of a stranger; if neglected it is probably that of a slave. But as slaves were often buried with their owners, even this is not a positive conclusion. Among some of the Pacific tribes, however, compression of the head is confined to females, or is, at any rate, only carried to extent by them. Slaves are sometimes of the same tribe with their owners, but they are more frequently purchased from others, and it should be noted that on the Pacific the course of the trade has been from south to north.

In order to ascertain whether differences of form exist among different stocks, the accumulation of as many specimens as possible of each tribe is desirable, and duplicates moreover afford the means of further collections by exchange.

Those skulls which have been altered in shape possess a certain interest in themselves, though they are in other respects disadvantageous for comparison. The process, in different forms, has once obtained more widely than at present, several tribes in the southern States, as the Natchez, &c., having been addicted to it. Two methods are still employed in North America: that of flattening the head by pressure on the forehead, as practiced among the Chinooks and other tribes in Oregon and Washington Territory, and that of elongating it, peculiar to a few on the northern end of Vancouver island.

SPECIMENS OF ART, ETC.

Another department to which the Institution wishes to direct the attention of collectors is that of the weapons, implements, and utensils, the various manufactures, ornaments, dresses, &c., of the Indian tribes.

Such a collection may naturally be arranged under three periods. The first, that of the races which had already passed away before the discovery of the continent by Europeans, or whose extinction may be considered as coeval with that event; next, of the tribes who have disappeared with the settlement of the Atlantic States and the country between the Alleghanies and the Mississippi; and finally, the present time, or that of the yet existing nations confined to the northern and western portions of the continent and to Mexico.

It is among the last that the greatest variety exists, and of which it is especially important to make immediate collections, as many articles are of a perishable nature, and as the tribes themselves are passing away or exchanging their own manufactures for those of the white race. It is hardly necessary to specify any as of particular interest, for almost everything has its value in giving completeness to a collection. Among the most noticeable, however, are dresses and ornaments, bows and arrows, lances, war clubs, knives, and weapons of all kinds, saddles with their furniture, models of lodges, parflesh packing covers and bags, cradles, mats, baskets of all sorts, gambling implements, models of canoes, (as nearly as possible in their true proportions,) paddles, fish-hooks and nets, fish spears and gigs, pottery, pipes, the carvings in wood and stone of the Pacific coast Indians, and the wax and clay models of those of Mexico, tools used in dressing skins and in other manufactures, metates or stone mortars, &c., &c.

In making these collections care should be taken to specify the tribes from whom they are obtained, and where any doubt may exist, the particular use to which each is applied. Thus, for instance, among the Californians one form of basket is used for holding water; another for sweeping the seeds from various plants and grasses; a third, as their receptacle during the process of collection; a fourth, for storage; still another, in which to pound them; again, one to boil the porridge made from the flour; and finally, others as dishes from which the preparation is eaten. It will also be desirable to ascertain the Indian names given to each article.

Of the second class the remains are also numerous, and are scattered through all the States east of the Mississippi in the form of axes, arrowheads, sinkers for nets, fleshing chissels, and other implements of stone, and in some cases fragments of rude pottery.

To the first class belong the only *antiquities* of America, and these are of various descriptions. They include the tools found in the northern copper mines; the articles enclosed in the mounds of Ohio and elsewhere; the images common in Kentucky and Tennessee, indicating, among other things, the worship of the Phallus; pottery,

the fragments of which are abundant in Florida, the Gulf States, and on the Gila, connecting an extinct with an existing art; and especially those specimens frequently disinterred in the Mexican States belonging to the era of Aztec or Toltecan civilization. It is especially important to ascertain the antiquity of these by careful observation of the circumstances under which they are discovered, in order not to confound ancient with modern utensils.

To this class also belong those articles found under conditions which connect archæology with geology, and which may be classed as follows:

1. The contents of shell beds of ancient date found on the seacoasts and bays, often deeply covered with soil and overgrown with trees, among which, besides the shells themselves, are frequently implements of stone, bones of fish, animals, and birds used for food. The examination of these collections in Denmark and other countries of northern Europe has led to the discovery of remains belonging to a period when a people having no other implements than those of stone occupied the coast prior to the settlement there of the present race. It is possible that a similar investigation in America may take us back to a very remote period in aboriginal history.

2. Human remains, or implements of human manufacture, bones of animals bearing the marks of tools or of subjection to fire, found in caves beneath deposits of earth and more especially of stalagmites or stony material formed by droppings from the roof.

3. Spear and arrowheads, or other weapons and evidences of fire discovered in connexion with bones of extinct animals, such as the mammoth, fossil elephant, &c., among superficial deposits, such as salt licks, &c.

4. Implements of the same description found in deposits of sand and gravel or other like material exposed in bluffs or steep banks, such as have recently attracted the attention of European geologists.

In all these cases the utmost care should be taken to ascertain with absolute certainty the true relations of these objects. In the case of the shell banks, the largest trees, where any exist, should, if practicable, be cut down and the annual rings counted. Next the depth of the superincumbent deposit of earth should be measured and its character noted, whether of gravel, sand, or decomposed vegetable matter, as also whether it has been stratified by the action of water. Next the thickness of the shell bed should be ascertained and the height of its base above present high water mark, as also whether it exhibits any marks of stratification. Finally, the face of the bed having been uncovered, a thorough examination should be made, commencing at the top and carefully preserving everything which exhibits signs of human art, and noting the depth in the deposit at which they were discovered. Specimens of each species of shell should be collected, and all bones or fragments of them saved. Evidences of fire having been used should be watched for and recorded.

In the search of caverns the same system should be followed. First, the floor should be inspected for any recent remains either of men or animals; next, the superficial earth should be carefully removed over

a considerable space and thoroughly examined at various depths, the results, if any, being kept separate and marked accordingly. Where a stalagmitic deposit, such as is common in limestone caverns, forms the floor, it must be broken up and its thickness measured. The underlying materials should then be cautiously removed and sorted over, each layer being kept by itself, and where any remains are discovered the utmost precaution should be taken to determine their actual circumstances. If, for instance, they are bones of men, it should be ascertained whether the skeleton is entire and in a natural position, indicative of having been buried there, or scattered, as also its position relative to any other remains, whether under or over them; if of animals, whether they exhibit the marks of tools, and above all, evidences of the employment of fire. Every fragment of bone or other evidence of animal life should thus be preserved and marked with the order of its succession in depth.

The same precautions should be taken in the other cases mentioned, the conditions under which the objects are found, and the depth and character of covering of each being noted, and full sets of specimens sent for examination.

CIRCULAR.

SMITHSONIAN INSTITUTION,
Washington, April 25, 1862.

The Smithsonian Institution is about to publish a communication on the ancient mining operations of the Lake Superior copper region, and is desirous of obtaining all the facts which have been discovered in later times in regard to this subject.

To attain this object, it is respectfully requested that all persons who have made original observations in regard to this matter will send an account of them to this Institution, and also specimens of implements, &c., of wood, stone, or copper which have been found in the vicinity of the ancient mines. These specimens will be carefully photographed and the originals, if requested, be returned to the owners.

Specimens and photographs of this kind, when collected together, afford the means by comparison of inferences of much interest in regard to the early history of man, particularly in connexion with the investigations of a similar kind now being prosecuted in Europe.

Mr. Jacob Houghton, mining engineer, Houghton county, Michigan, has kindly offered to take charge of any articles which may be presented or lent to the Institution, and they may be forwarded through him, or directly by Adams's Express, at the expense of this establishment.

JOSEPH HENRY,
Secretary Smithsonian Institution.

SUGGESTIONS

RELATIVE TO AN

ETHNOLOGICAL MAP OF NORTH AMERICA,

36 by 44 INCHES.

BY LEWIS H. MORGAN, OF ROCHESTER, N. Y.

It should show—

I. Ocean boundaries: with the straits of Behring, the Aleutian islands, and the direction of the North Atlantic ocean currents.

II. River system, with the small tributaries complete.

III. Mountain ranges: to be indicated strongly. 1. Great ranges: these to be named; whether wooded or sterile, to be shown. 2. Cross or transverse ranges; the same.

IV. Profiles showing the elevations of the continent on every fifth parallel: to be drawn on the parallels, as now shown on the Smithsonian map.

V. Prairie and forest areas: 1. Arable prairie; to be shown as on Smithsonian map in Patent Office report, but with a further discrimination as follows: where there is a mixture of forest and prairie, as is the case particularly east of the Mississippi, if the forest predominates use one indication; if the prairie predominates use another. 2. Dry prairie; to be shown as on the Smithsonian map.

VI. Show the limits of the Colorado desert or basin, as far as they are known.

VII. Show the barren grounds west of Hudson bay.

VIII. Isothermal lines.

IX. Amount of annual precipitation in figures, for the purpose of showing the comparative wetness or dryness of different areas—no shading.

X. Boundary lines of States and Territories, with the initials of each.

XI. Location and distribution of the embankments and eathworks of the mound builders.

When the map is thus far completed by a draughtsman, there may be added as follows:

XII. Boundaries of the territories of the several stock Indian families, each one to be shaded with a different color: 1. Stock families. 2. Nations constituting each family, and their location. 3. Location of principal villages or settlements. 4. Geographical Indian names of rivers, lakes, and localities, &c.

XIII. Date of map: 1. East of the Mississippi and the Red River

of the North, the map to show the position of Indian nations A. D. 1600—1700. 2. Interior of the continent; the map to show the position of Indian nations A. D. 1700—1800. 3. West coast and Hudson's bay territory, A. D. 1800—1862. 4. Mexico and Central America, A. D. 1520—1600.

For ordinary geographical features, besides standard maps, consult—

For British America: Richardson's map, volume I; Sir John Richardson's Journal of a Boat Voyage, &c. Also, maps accompanying "Report on the Explorations of the Country between Lake Superior and the Red River Settlement," made to the Canadian Parliament; printed at Toronto, 1858.

West of the Mississippi, and the Pacific coast: United States military map.

For New Mexico, Texas, and northern States of Mexico: Bartlett's map; J. R. Bartlett's Personal Narrative, volume I; and for the course of the Colorado, Ives's Colorado Report.

For Central America: Squeir's map, in his work on Central America; also, United States map of same in House of Representatives "Report on Central American Affairs and Enlistment Question," 1856.

For Mexico, 1520—1600: consult Clavigero's map; Clingen's History of the Conquest of Mexico, volume VI; also, De Solis's map; De Solis's Conquest of Mexico, volume I.

NATURAL HISTORY.

LIST OF BIRDS ASCERTAINED TO INHABIT THE DISTRICT OF COLUMBIA, WITH THE TIMES OF ARRIVAL AND DEPARTURE OF SUCH AS ARE NON-RESIDENTS, AND BRIEF NOTICES OF HABITS, ETC.

BY ELLIOTT COUES AND D. WEBSTER PRENTISS.

From the central situation of the District of Columbia, with regard to the northern and southern sections of the country, together with the varied character of surface which it presents, it might be expected to possess a rich and interesting *avi-fauna*. Such has been found to be the case. It seems to be on the natural dividing line between the true northern and southern faunas, it being impossible to decide which takes precedence. Therefore, if we except a few peculiarly favored regions, we are enabled to present a more extensive list of species inhabiting the district than has been given for almost any other locality in eastern North America.

Though the number of birds which are resident throughout the year and those which breed here is considerable, they are few in comparison with those which pass through during their spring and autumn migrations, and remain for a longer or shorter time each season. The number of species, indeed, is not greater, but the individuals of each are very numerous. It is on this account that for a month or so during the spring and autumn—from about the 20th of April to the 20th of May, and from the 1st of September to the middle of October—the collector is so amply repaid for his pains, while at other times ornithologizing, except for some particular birds, is hardly worth the time and trouble. So numerous, indeed, are individuals of most of the migratory species that at the height of the season in spring we have collected, in a walk before breakfast, from forty to fifty specimens of various species of warblers, thrushes, flycatchers, finches, &c. As an instance of the number of birds which pass through the District on their way north to breed, compared with those which remain with us during the summer, may be cited the wood-warblers, or *Dendroicæ*. Of the twelve or thirteen wood-warblers found more or less abundantly in the spring and fall, only three are known to breed here. The same might be affirmed of other birds, as the thrushes, flycatchers, sandpipers, &c.

Though there is included in the list only those species which have been positively detected, there are some of which specimens have been obtained, and yet are not entitled to be considered as inhabitants of the District. These may be divided into three classes: First, those which visit us in severe winters, being driven south, out of

their usual range, by scarcity of food or other causes; such are the *Nyctea nivia*, *Astur atri capillus*, *Collyrio borealis*, *Pinicola canadensis*, and others. Second, those which visit us in July and August, which are mostly the young of species breeding further south. Examples of these are to be seen in the *Rhynchops nigra*, some species of *Ardeidæ*, &c. In the third class are to be ranged those whose appearance is totally accidental, dependent upon no fixed habit of the bird. Thus, species of *Thallassidroma* and *Puffinus* have been seen upon the Potomac, and a *Milvulus* (M. *forficatus*, probably) and the *Chamæpelia passerina* have been detected.

The great mass of the birds which pass through the district in their spring migrations do not stop to breed before reaching, at least, the New England States, and probably the majority go still further north, spreading through the Canadas and into British America to the region around Hudson's bay. Our regular winter visitants, as the *Junco hyemalis*, *Spizella monticola*, and the *Anatidæ*, generally do not usually stop much short of Labrador and the regions of that latitude. Other species, however, breed with equal readiness in almost any latitude. Thus the *Dendroica aestiva* is very common through the summer in the district, and doubtless even further south; while it breeds also in very high latitudes in British America. During the winter these migratory species mostly retire to the Antilles, or into Central America, though many linger in the Gulf States along our southern border. The manner in which these extensive migrations are performed varies, doubtless, with different groups of birds, but it is very difficult to conceive how some weak and short-winged species can perform the immense journey. Some accomplish the distance by continually flying from forest to forest, and from hedge to hedge; while others mount directly high into the air, and uninterruptedly continue their flight until hunger or weariness compels them to desist for awhile. This kind of migration is performed by some species wholly in the night time. Some of the small insectivorous birds have been noticed just at daybreak to descend from a great height, and after remaining motionless for sometime, as if to recuperate their energies, search diligently for food, and again resume their flight towards evening. The distance at which the notes of birds flying overhead can be heard is truly surprising. We have heard distinctly the mellow notes of the *Bob-o'link* while the bird itself was entirely beyond our range of vision. The loud "honking" of wild geese while migrating is well known.

A circumstance which has considerable influence on the appearance of birds in the immediate vicinity is the presence of a large city. This is most strikingly shown in the case of the ducks and other water fowl, to which the attention of the sportsman is especially directed. The peculiar character of Chesapeake bay and its tributaries render them the favorite winter resort of nearly all the species of *Anatidæ*; but the incessant persecutions to which these birds are subjected have effected a material diminution of their numbers, and caused a great part of them to retire to the bogs and inlets of more southern shores. The same is true, though less markedly, of various

shy and solitary birds, (as, for example, the *Hylatomus pileatus*,) which are gradually retiring with the clearing up of the forests to more mountainous and inaccessible regions. Nevertheless, the pertinacity with which some birds hold their ground is surprising. Thus the common partridge, though so continually persecuted by sportsmen, is still very numerous, even in the immediate vicinity of the city. A total change of habit by civilization, sometimes to be observed, is extremely interesting. There can be no doubt that before the settlement of the country the *Chaetura pelasgia* bred in hollow trees. This habit is now totally lost, the bird finding chimneys better suited to its wants. In like manner, the *Hirundo horreorum* now breeds altogether on the rafters and beams of barns and outhouses, while the *H. lunifrons* is gradually abandoning the sides of cliffs for the convenient situations afforded by the projecting eaves of buildings. The *Progne purpurea* always gives preference to the boxes now everywhere placed for its accommodation.

With these brief and very cursory remarks, which might be greatly extended did space permit, we proceed to the list of the species ascertained to inhabit the District. Our observations, from which the paper has been prepared, have extended over a period of nearly five years, during which all the time that could be spared from other occupations has been devoted to the study of birds. No species has been admitted which has not been actually detected in the District or its immediate vicinity. A few of whose existence there can be little or no doubt, are included in brackets, but still are not counted in the list. The date given for the arrival and departure of any bird is the mean of those observed during each successive year, since the appearance and disappearance of birds depend somewhat on the early or late advance of the season. It is regretted that the account of some of the water birds is so scanty and incomplete; but it is hoped that the very full details of most of the land birds will in a measure atone for the deficiency in this respect.

1. *Cathartes aura*, (Linn.,) Ill.—Turkey Buzzard. Permanent resident. Abundant. Not ordinarily gregarious, but collects in great numbers where offal of any description is exposed.

2. *Falco columbarius*, Linn. Pigeon Hawk. Rather rare, but few having been observed. Very shy. Sometimes exposed for sale in the market.

3. *Falco (Tinnunculus) sparverius*, Linn. Sparrow Hawk. Resident. Abundant. Generally found in open fields, about hedges, stumps, dead trees, &c.

4. *Astur atricapillus*, (Wils.,) Bon.—Goshawk. Very rare; only occasionally observed during the winter months.

5. *Accipiter cooperi*, Bon.—Cooper's Hawk. Resident. One of the most common hawks. Frequents chiefly open fields, searching for mice, small birds, &c.

6. *Accipiter fuscus*, (Gm.,) Bon.—Sharp-shinned Hawk. Resident. Very abundant, and the least shy of the hawks. Frequents hedges, ditches, brier patches, &c.

7. *Buteo borealis*, (Gm.,) Vieill.—Red-tailed Hawk. "Hen Hawk." Resident. Abundant, especially in winter. Very shy and wary. Generally seen upon the largest trees in open fields.

8. *Buteo lineatus*, (Gm.,) Jard.—Red-shouldered Hawk. "Chicken Hawk." Resident. Common. Habits much like those of the preceding, with which it is generally confounded by farmers.

9. *Buteo pennsylvanicus*, (Wils.,) Bon.—Broad-winged Hawk. Very rare; only occasionally observed. Specimens have been obtained in the market.

[*Nauclerus furcatus*, Vig.—Swallow-tailed Kite. As this bird goes considerably further north, it doubtless is to be found in the District, though we have never detected it.]

10. *Circus hudsonicus*, (Linn.,) Vieill.—Marsh Hawk. Resident. Very abundant. Generally seen over the marshes of the rivers, and the wet meadows north of the city.

11. *Aquila canadensis*, (Linn.,) Cass.—Golden Eagle. Apparently not rare; individuals being observed or taken almost every winter. Two specimens from this locality are now in the museum of the Smithsonian Institution.

12. *Haliætus leucocephalus*, (Linn.,) Savig.—Bald-headed Eagle. Not rare. Frequently seen sailing along over the river and perched upon stumps and snags upon the "flats." Resident.

13. *Pandion carolinensis*, (Gm.,) Jard.—Fish Hawk. Osprey. Common. Seen over the Potomac and Anacostia rivers, and upon the branches of dead trees overhanging their banks.

14. *Scops asio*, (Linn.,) Bon.—Screech Owl. The most abundant as well as the smallest of the owls. This as well as the other owls are comparatively seldom seen on account of their nocturnal habits.

15. *Bubo virginianus*, (Gm.,) Bon.—Great Horned Owl. "Cat Owl." Not common. Sometimes offered for sale in the market. Seldom seen, but its note often heard in woods, "making night hideous."

16. *Otus wilsonianus*, Lesson.—Long-eared Owl. More abundant than the preceding. Seldom seen. Passes the day in hollow trees, thick clumps of pines, &c.

17. *Brachyotus cassinii*, Brew.—Short-eared Owl. Very abundant. Less shy than preceding, and apparently more confused by the light of day. Has been caught in the streets of the city.

18. *Syrnium nebulosum*, (Forst.,) Gray.—Barred Owl. Rare. But a few specimens observed. Found chiefly in day time in close cedar thickets, near farm houses.

19. *Nyctea nivea*, (Daud.,) Gray.—Snowy Owl. Very rare; only occasionally observed during the severest weather in winter.

[*Nyctale acadica* may very probably be hereafter detected.]

20. *Coccygus americanus*, (Linn.,) Bon.—Yellow-billed Cuckoo. "Rain Crow." Very abundant, especially in spring and fall. Found chiefly in open woods. Breed plentifully. Fresh eggs are often found in a nest with young birds. Arrives May 1; departs late in September.

21. *Coccygus erythrophthalmus*, (Wils.,) Bon.—Black-billed Cuckoo. "Rain Crow." Less abundant than the preceding, but not at all

rare. Habits similar to those of the Yellow-billed Cuckoo. Note not so harsh and prolonged. Summer resident. Arrives May 1; departs late in September.

22. *Picus* (*Trichopicus*) *villosus*, Linn.--Hairy Woodpecker. Permanent resident. Apparently rare. General habits in common with the woodpeckers. Not at all shy.

23. *Picus* (*Trichopicus*) *pubescens*, Linn. — Downy Woodpecker. "Sapsucker." Resident all the year. Abundant. Breeds plentifully. Frequents chiefly orchards, the dead undergrowth of boggy marshes, and the more open cleared woods.

24. *Sphyropicus varius*, (Linn.,) Baird.—Yellow-bellied Woodpecker. Resident all the year. Abundant, particularly in the fall. Frequents chiefly high open woods, but often seen in thickets and tangled copses. Very fond of the berries of the sour gum.

25. *Hylatomus pileatus*, (Linn.,) Bd.—Pileated Woodpecker. "Cock of the Woods." "Black Log-Cock." Probably permanent resident. Rare, having retired from the immediate vicinity with the clearing off of the forests. Excessively shy and wary when seen.

26. *Centurus carolinus*, (Linn.,) Bon.—Red-bellied Woodpecker. Resident all the year; rather rare, and apparently more so than formerly.

27. *Melanerpes erythrocephalus*, (Linn.,) Sw.—Red-headed Woodpecker. "Red-head." Summer resident; high open woods and orchards. The most abundant of the woodpeckers. Arrives in spring usually the last week in April; leaves about the middle of September.

28. *Colaptes auratus*, (Linn.,) Sw. — Yellow-shafted Woodpecker. "Flicker." Resident all the year. Very abundant, particularly in spring and fall, when usually seen in straggling flocks. Breeds plentifully.

29. *Trochilus colubris*, Linn. — Ruby-throated Humming Bird. Summer resident. The only Humming Bird found here. Abundant, especially in the fall. Frequent exclusively the gardens in the city, patches of wild flowers, (golden rod, &c.,) along the sides of branches. Breed plentifully in the high woods. Arrive in spring about May 1, and remain till the first approach of cool weather.

30. *Chœtura pelasgia*, (Linn.,) Steph.—Chimney Swift. Very abundant. Mostly seen in the city. Arrives second week in April; leaves towards the end of September.

31. *Antrostomus vociferus*, (Wils.,) Bon.—Whip-poor-will. Rare. Summer resident. Arrives first week in May; leaves third week in September. When suddenly startled flies off in a confused zigzag manner, unless during the breeding season.

32. *Chordeiles popetue*, (Vieill.,) Bd.—Night Hawk. "Bull Bat." Spring and autumn visitant. A few breed. Arrives May 1; leaves about October 6. Very abundant in the fall, especially just before its departure.

33. *Ceryle alcyon*, (Linn.,) Boie.—Kingfisher. Summer resident. Quite common along the banks of the rivers and Rock creek. Rather shy. Arrives the third week in March; leaves early in October.

34. *Milvulus* ——— ?—A Milvulus was seen, but, unfortunately,

not obtained, May 6, 1861, by Mr. C. Drexler. It was probably *M. forficatus.*

35. *Tyrannus carolinensis*, (Linn.,) Bd.—King Bird. "Bee Martin." Summer resident; breeds plentifully, but the greater number go further north. Arrives second week in April; leaves late in September.

36. *Myiarchus crinitus*, (Linn.,) Cab.—Great-crested Flycatcher. Common summer resident, but most numerous in spring and autumn. Arrives third week in April; leaves third week in September.

37. *Sayornis fuscus*, (Gm.,) Bd.—Pewee. "Tom-tit." Common summer resident, but more plentiful in spring and fall, since the greater number go further north to breed. Arrives the *first* of the spring visitants, about the first of March, and is very abundant for a month or more; in autumn becomes numerous about September 25, and does not leave till near the middle of October. Breeds in caves, about rocks, creeks, bridges, &c.

38. *Contopus virens*, (Linn.,) Cab.—Wood Pewee. Excessively abundant summer resident. Arrives last week in April; becomes very abundant in two weeks; leaves third week in September.

39. *Empidonax traillii*, (Aud.,) Bd.—Traill's Flycatcher. Rare; spring and fall visitant; perhaps a few breed. Times of arrival and departure much those of the succeeding.

40. *Empidonax minimus*, Baird.—Least Flycatcher. Spring and autumn visitant; none breed; rather common, most so in the spring. Frequents *exclusively* the margins of small streams and brooks, briar patches, &c. Arrives last week in April, remains about two weeks; arrives in autumn, third week in August, and remains till third week in September.

41. *Empidonax acadicus*, Gm., Bd.—Acadian Flycatcher. Common summer resident; the most abundant of the *Empidonaces*, and the only one that breeds here in any numbers. Arrives last week in April; leaves about September 25.

42. *Empidonax flaviventris*, Bd. — Yellow-bellied Flycatcher. Spring and autumn visitant; rather rare; perhaps some breed, specimens having been taken July 28. Arrives the first week in May; in autumn remains until third week in September. Found in same situations as *E. minimus.*

43. *Turdus mustelinus*, Gm.—Wood Thrush. "Wood Robin." Summer resident. Many breed, but the greater number go further north. Arrives last week in April; leaves last week in October. Frequents thick and tangled woods, especially laurel brakes, &c., along the banks of Rock creek.

44. *Turdus pallasi*, Cab.—Hermit Thrush. Spring and autumn visitant; none breed. Arrives much the earliest of all the thrushes, and immediately becomes very abundant. Frequents chiefly open woods. Arrives third week in March, and remains until May; arrives in the fall the first week in October, and leaves about the third.

45. *Turdus fuscescens*, Steph.—Tawny Thrush. Spring and autumn visitant. Rather uncommon, being the rarest of the thrushes. Does not usually arrive until the first week in May; remains but a short

time; returns early in the fall. Frequents high open woods, but keeps near the ground. Shy and solitary.

46. *Turdus swainsoni*, Cab.—Olive-backed Thrush. Spring and autumn visitant; none breed. The most abundant of the thrushes, except perhaps *T. pallasi*. Have seen them in considerable flocks in the fall. Arrives the second week in April; remains but a short time. Returns in the fall, second week in September; remains till second week in October.

47. *Turdus aliciae*, Bd.—Gray-cheeked Thrush. Spring and autumn visitant; none breed. Apparently as abundant as *T. swainsoni*, more so than *T. fuscescens*. Found in similar situations with the former, with which its times of arrival and departure are nearly identical; perhaps fonder of swampy localities. (First shown to belong to the eastern Avi-fauna by ourselves. See Proc. Acad. Nat. Sci., Philada., Aug., 1861.)

48. *Turdus (Planesticus) migratorius*, Linn.—Robin. Permanent resident. A few breed, and a few remain during the winter; the greater part, however, proceed north in summer and south in winter. Most abundant in November and March. Sour gum and poke-berries (*Phytolacca decandra*) are their favorite food. Found in all localities. Many nest in the parks about the Capitol and President's House.

49. *Sialia sialis*, (Linn.,) Bd.—Blue Bird. Very abundant. Permanent resident. Disappears in severe weather in winter, but is found on warm, sunny days throughout that season, and becomes exceedingly numerous on the first opening of spring. Breeds plentifully in holes of trees and in boxes throughout the city.

50. *Regulus calendulus*, (Linn.,) Licht.—Ruby-crowned Kinglet. Spring and autumn visitant. Very abundant. None breed. In spring, from April 1 to May 10; in fall, through the month of October and first few days in November. Frequents orchards, thickets, copses, cedar patches, &c.; less frequently found in high woods. Is most numerous in the fall. Is in full song before it leaves. Spring migrations always embrace a number of both sexes, with the head perfectly plain.

51. *Regulus satrapa*, Licht.—Golden-crested Kinglet. Winter resident. Abundant from October 1 to latter part of April. None breed. Habits much the same as the preceding. Thick pine woods a favorite resort. Familiar and unsuspicious.

52. *Anthus ludovicianus*, (Gm.,) Licht.—Titlark. "Skylark." Winter resident. Abundant. Makes its appearance towards the end of October, and remains until April. Always found in restless straggling flocks, usually of considerable extent. Frequents open commons, bare meadows, ploughed fields, &c. Has a remarkable habit of frequently alighting on the roofs of houses and sheds. [Breeds in great numbers in Labrador.]

53. *Mniotilta varia*, (Linn.,) Vieill.—Black and White Creeper. "Sapsucker." Very common summer resident, but more abundant in spring and fall, as the greater number go further north to breed. Arrives first week in April, and is exceedingly numerous until May. Breeds in holes in trees. Generally found in high, open woods.

54. *Parula americana*, (Linn.,) Bon.—Blue Yellow-back Warbler.

Spring and autumn visitant. Exceedingly abundant from April 25 till May 15. Perhaps a few breed, as we have found them the first week in August. In fall abundant from August 25 to second week in October. Inhabits exclusively high, open woods, and usually seen in the tops of the trees, or at the extremities of the branches, in the tufts of leaves and blossoms. (*Albino* obtained.)

55. *Protonotaria citrea*, (Bodd.,) Bd.—Prothonotary Warbler. Exceedingly rare; perhaps only an accidental visitor. An individual seen in a swampy briar patch May 2, 1861. Probably its most northern range, if regularly found here.

56. *Geothlypis trichas*, (Linn.,) Cab.—Maryland Yellow-throated Warbler. Very abundant summer resident, breeding in great numbers. Arrives April 25, becoming exceedingly numerous on its first appearance. Remains until October. Inhabits the densest briar patches, generally in swampy situations. Never seen in high woods, seldom in orchards or hedgerows. Associates with *Cistothorus palustris*, in the *Zizania aquatica* marshes. Nest on ground.

[*G. philadelphia* is undoubtedly an inhabitant of the District.]

57. *Oporornis agilis*, (Wils.,) Bd.—Connecticut Warbler. Rather uncommon in the fall, during the month of October. Excessively rare in spring; we never have seen it in that season. Frequents old buckwheat and corn fields, searching for food among the dry, rank weeds; also low thickets in swampy places.

58. *Oporornis formosus*, (Wils.,) Bd.—Kentucky Warbler. Rare. Found chiefly in low woods with thick undergrowth, ravines, &c. Very silent, but not shy. A few breed here.

59. *Icteria viridis*, (Gm.,) Bon.—Yellow-breasted Chat. Summer resident, breeding very abundantly. Arrives the last week in April, leaves about the middle of September. Frequents exclusively most dense and impenetrable briar patches. Males exceedingly shy and difficult to procure until the females commence incubation, when they are quite the reverse.

60. *Helmitherus vermivorus*, (Gm.,) Bon.—Worm-eating Warbler. Rathen uncommon summer resident, breeding sparingly. Arrives first week in May, remains till third week in September. Slow and sedate in its movements.

61. *Helminthophaga chrysoptera*, (Linn.,) Cab.—Golden-winged Warbler. Spring and autumn visitant. Very rare.

62. *Helminthophaga pinus*, (Linn.,) Baird.—Blue-winged Yellow Worm-eating Warbler. Spring and autumn visitant. Very rare.

63. *Helminthophaga ruficapilla*, (Wils.,) Bd.—Nashville Warbler. Spring and autumn visitant. Rare.

64. *Helminthophaga peregrina*, (Wils.,) Cab.—Tennessee Warbler. Spring and autumn visitant. Very rare.

[Our observations warrant the belief that all the *Helminthophageæ* are exceedingly rare. Though the four species given have been detected, the data with regard to their arrival and departure have not been ascertained.]

65. *Sciurus aurocapillus*, (Linn.,) Sw.—Golden-crowned Wagtail. Exceedingly abundant summer resident. Arrives April 12; for about two weeks keeps perfectly silent, hiding in the thickets and

laurel brakes, (*Kalmia latifolia,*) so that its loud, harsh notes are not heard until the first of May, when they fill the woods, greatly to the annoyance of the collector searching for rarer and more retiring species. Found in high woods, especially where there is an undergrowth. Is *not* aquatic in any sense, but keeps on the ground rustling among the dry leaves for insects, and when disturbed flies to the nearest tree.

66. *Seiurus noveboracensis*, (Gm.,) Nutt.—Water Wagtail. Quite common in spring and fall; also breeds sparingly, having been found in July. Arrives in spring about May 1. Is eminently aquatic; swampy thickets, thick gloomy woods interspersed with puddles, where it associates with *Rhyacophilus solitarius*, are favorite resorts.

67. *Seiurus ludovicianus*, (Vieill.,) Bon.—Large-billed Water Wagtail. This bird, generally considered so rare, we have found to be not at all uncommon at certain seasons in particular localities. From the 20th of April to the 10th of May it may always be obtained, by an acute collector, in the dense laurel brakes which border the banks of and fill the ravines leading into Rock creek and Piney branch. We think we have seen it in June, which would prove it to breed here, as is, indeed, very probable. We have not detected it in the fall. It is usually very shy, darting at once into the most impenetrable brakes; but we have sometimes seen it quite the reverse, and have shot a pair, one after the other, as they sat in full view before me unconcernedly wagging their tails. We have nearly always found it in *pairs*, even as early as April 20. Its note is a sparrow-like chirp, like that made by striking two pebbles together; but it has also a loud and most beautiful and melodious song, the singularity of which first drew our attention to it.

68. *Dendroica virens*, (Gm.,) Bd.—Black-throated Green Wood-warbler. Spring and autumn visitant. None breed. In spring, from May 1 to 20; in fall, from September 7 to October 1. High open woods. Abundant.

69. *Dendroica canadensis*, (Linn.,) Bd.—Black-throated Blue Wood-warbler. Like the preceding, but rather less numerous.

70. *Dendroica coronata*, (Linn.,) Gray.—Yellow-rumped Wood-warbler. Winter resident. Exceedingly abundant. Arrive second week in October and remain until second week in May. Moult during the whole month of April, but before they leave are in full spring dress, though they have no song here. Most abundant in April and October, less so in depth of winter. Fond of hedges, orchards, copses, &c., but found everywhere. (*Albino* obtained.)

71. *Dendroica blackburniae*, (Gm.,) Bd.—Blackburnian Wood-warbler. Spring and autumn visitant. None breed. In spring, from May 1 to 20; in fall, from September 1 to 25. High open woods. Common.

72. *Dendroica castanea*, (Wils.,) Bd.—Bay-breasted Wood-warbler. Spring and autumn visitant. None breed. May 1 to 20; September 1 to 30. More abundant in fall than in spring. High open woods; sometimes laurel brakes, &c.

73. *Dendroica pinus*, (Wils.,) Bd.—Pine-creeping Wood-warbler. Summer resident. Arrives early in March, and stays until October.

Not very abundant at any time, and breeds but sparingly. High open woods. Pine and spruce forests.

74. *Dendroica pennsylvanica*, (Linn.,) Bd.—Chestnut-sided Wood-warbler. Spring and autumn visitant. None breed. In spring, from May 1 to 25; in fall, from September 1 to 20. High open woods. Abundant.

75. *Dendroica striata*, (Forst.,) Bd.—Black-poll Wood-warbler. Spring and autumn visitant. None breed. In spring, from May 7 to June 1; in fall, September 7 to second week in October. Arrive latest in both spring and fall, and stay latest of all the migratory warblers. Are the most numerous at both seasons, but especially abundant in the fall. High open woods.

76. *Dendroica aestiva*, (Gm.,) Bd.—Summer Yellow Wood-warbler. Summer resident. Very abundant. Breeds in numbers throughout the city, placing the nest in the forks of garden and fruit trees. Arrives April 25; leaves early in September. Never found in high open woods with the other Dendroicæ, but frequents orchards, gardens, &c.; also swampy copses.

77. *Dendroica maculosa*, (Gm.,) Bd.—Black and Yellow Wood-warbler. Spring and autumn visitant. None breed. Arrives first week in May; remains till the third. In fall, from September 1 to October 7. High open woods. Abundant.

78. *Dendroica tigrina*, (Gm.,) Bd.—Cape May Wood-warbler. Exceedingly rare. A single specimen obtained September 12, 1859. Times of arrival and departure probably identical with those of D. virens, canadensis, &c.

79. *Dendroica superciliosa*, (Bodd,) Bd.—Yellow-throated Wood-warbler. Entirely accidental visitor. One specimen obtained in 1842, and now in Smithsonian collection.

80. *Dendroica discolor*, (Vieill.,) Bd.—Prairie Wood-warbler. Mostly spring and autumn visitant, being quite abundant during those seasons. A few, however, breed. Arrives earlier than most of the Dendroicæ, about April 20. Frequents almost exclusively cedar patches and pine trees, and has very peculiar manners and notes.

81. *Dendroica palmarum*, (Gm.,) Baird.—Yellow Red-poll Wood-warbler. Spring and autumn visitant. Rather rare. None breed. Arrives about May 1; in fall, late in September, and does not leave till middle of October, after all the other warblers but Dend. coronata have taken their departure. Frequents old corn and buckwheat fields, associating with various species of sparrows; differing in this respect from all others of its genus, and resembling Oporornis agilis.

[There are twenty-two species of Dendroica found in North America; of these, fourteen have been observed here. Not one is a permanent resident; three only (D. pinus, aestiva, discolor) breed; one (D. coronata) is a winter resident. Nine others are spring and fall visitants; of these, seven (D. virens, canadensis, blackburniae, castanea, pennsylvanica, striata, maculosa) do not differ materially in numbers, habits, or times of arrival and departure; one (D. palmarum) differs in times of arrival and departure, and very remarkably in habits; one (D. superciliosa) is an accidental visitor; one (D. tigrina) is exceed-

ingly rare. In addition, Dendroica cærulea is undoubtedly to be found here.]

82. *Myiodioctes mitratus*, (Gm.,) Aud.—Hooded Warbler. Rare spring and autumn visitant. Perhaps some breed.

83. *Myiodioctes pusillus*, (Wils.,) Bon.—Green Black-capped Flycatcher. Rare spring and autumn visitant. A few may breed.

84. *Myiodioctes canadensis*, (Linn.,) Aud.—Canada Flycatcher. Spring and autumn visitant. Abundant. Frequents high, open woods, keeping mostly in the lower branches of the trees, and also the more open undergrowth of marshy places. Arrives the last week in April, and remains about two weeks; arrives in fall the first week in September; and stays until the fourth.

85. *Setophaga ruticilla*, (Linn.,) Sw.—Redstart. Chiefly spring and autumn visitant. But very few breed. Exceedingly abundant in spring from April 25 to May 20, and in fall from September 1 to 20; in all woody or swampy situations. Has a habit of running along little twigs sideways. Note very similar to that of *Dendroica æstiva*.

86. *Pyranga rubra*, (Linn.,) Vieill.—Scarlet Tanager. Spring and autumn visitant. A few breed. In spring, from first to last week in May; in fall, from September 1 to 20. Common, but only found in high, open woods.

87. *Pyranga æstiva*, (Linn.,) Vieill.—Summer Red Bird. Summer resident. Not abundant. Arrives May 1; leaves towards the latter part of September. Frequents entirely high woods, especially those that have much undergrowth.

88. *Hirundo horreorum*, Barton.—Barn Swallow. Exceedingly abundant summer resident. Arrives March 25, and remains until September 12. Breeds in barns, out-houses, &c.

89. *Hirundo lunifrons*, Say.—Cliff Swallow. Summer resident, but not so abundant as preceding, from scarcity of good breeding places. Arrives last week in April, and remains until September 12.

90. *Hirundo bicolor*, Vieill.—White-bellied Swallow. Summer resident. Common, but not nearly so much so as *H. horreorum*. Arrives first week in April, and remains until third week in September.

91. *Cotyle (Cotyle) riparia*, (Linn.,) Boie.—Bank Swallow. Summer resident; the most abundant of the swallows; more so in fall than in spring. Arrives second week in May; departs about the middle of September. Eminently gregarious at all seasons. (*Albino* obtained.)

92. *Cotyle (Stelgidopteryx) serripennis*, (Aud.,) Bon.—Rough-winged Swallow. Summer resident. Rather rare. Arrives third week in April; leaves about the middle of September.

93. *Progne purpurea*, (Linn.,) Boie.—Purple Martin. Summer resident. Common. Arrives May 1; leaves first week in September. Many breed in the city and about the public buildings.

94. *Ampelis cedrorum*, (Vieill.,) Bd.—Cedar Waxwing. "Cedar Lark." Resident all the year. Abundant, particularly in the fall. Gregarious; almost always seen in flocks. Breeds latest of the summer residents, being in flocks as late as first week in June.

95. *Collyrio borealis*, (Bon.,) Bd.—Great Northern Shrike. Very

rare. Perhaps its southern limit. Seen only in severe winter weather.

96. *Vireo (Vireosylvia) olivaceus*, (Linn.,) Vieill.—Red-eyed Vireo Summer resident. Found in all the high, open woods, from April 20 to September 25. The most abundant summer resident.

97. *Vireo gilvus*, (Vieill.,) Bon.—Warbling Vireo. Summer resident. Common. Arrives April 20, and remains until September 20. Frequents orchards, gardens, &c.; also, sometimes, low, thick swamps, and is especially abundant *in the city*, breeding in the high sycamore and poplar trees. Very seldom seen in woods with other vireos.

98. *Vireo (Lanivireo) solitarius*, (Wils.) Vieill.—Blue-headed Vireo. Spring and autumn visitant. (Some breed?) Arrives in spring April 25; leaves in fall October 20. Rarest of the *vireos*. Inhabits high, open woods, associating with *V. olivaceus* and *V. flavifrons*.

99. *Vireo (Lanivireo) flavifrons*, Vieill.—Yellow-throated Vireo. Summer resident. Abundant. Arrives April 25; remains until September 25. High, open woods. [*Vireo philadelphicus*, Cass., has never been actually detected, but is undoubtedly a very rare inhabitant of the District.]

100. *Mimus polyglottus*, (Linn.,) Boie.—Mocking Bird. Summer resident; but rare. Arrives April 25; departs about the middle of September.

101. *Mimus carolinensis*, (Linn.,) Gray.—Cat Bird. Summer resident. Exceedingly abundant. Found in all briar patches, along fences, and in thickets. Arrives in spring, the 3d week in April. Seems rather careless in concealing its nest, but very solicitous in protecting it. Departs about October 15.

102. *Harporhynchus rufus*, (Linn.,) Cab.—Thrasher. "French Mocking Bird;" "Sandy Mocking Bird." Summer resident. Abundant. Arrives April 20, departs first week in October.

103. *Thriothorus ludovicianus*, (Linn.,) Bon.—Great Carolina Wren. Permanent resident. Not abundant, but most so in the summer; breeds in thick shrubbery, &c., about gardens; at other seasons is very shy and unfamiliar.

104. *Cistothorus (Telmatodytes) palustris*, (Wils.) Bd.—Long Billed Marsh Wren. Summer resident. Arrives 3d week in April, leaves early in October. Very abundant, but only in certain localities; chiefly in the tracts of *Zizania aquatica*, which border the Potomac and Anacostia rivers [*Cistothorus stellaris*, though we have not been able to detect it, is doubtless found sparingly here.]

105. *Troglodytes œdon*, Vieill.—House Wren. Summer resident. Very abundant. Arrives April 15, leaves October 20. Breeds in boxes, out-houses, sheds, &c., and in orchards.

106. *Anorthura hyemalis*, (Wils.)—Winter Wren. Winter resident; rather uncommon. Arrives 1st week in October; remains until latter part of April. Frequents thick briar patches in dark woods, and the rocks and gullies about ravines and the sides of creeks.

107. *Certhia americana*, Bon.—Brown Creeper. Resident all the year. High, open woods. Abundant.

108. *Sitta carolinensis*, Gm.—White-bellied Nuthatch. Resident all the year. Very abundant, especially in fall. High, open woods.

109. *Sitta canadensis*, Linn.—Red-bellied Nuthatch. Winter resident. Arrives early in October, and remains until May. Rather rare. High, open woods, pine forests.

110. *Polioptila cœrulea*, (Linn.,) Sclat.—Blue-Gray Gnatcatcher. Summer resident. Arrives early, the first week in April; remains until latter part of September. Very abundant. Breeds in high, open woods; on its first arrival frequents tall trees on the sides of streams, orchards, &c.

111. *Lophophanes bicolor*, (Linn.,) Bon.—Permanent resident, but the greater number breed further north. Exceedingly abundant, especially in fall. Found in all situations.

112. *Parus atricapillus*, Linn.—Black-capped Chick-a-dee. Winter resident.

113. *Parus carolinensis*, Aud.—Carolina Chick-a-dee. Summer resident. (Owing to the close resemblance of these two species, we have not been able to detect their times of arrival and departure.)

114. *Eremophila cornuta*, (Wils.,) Boie.—Sky-lark. Winter resident. Arrives November 1; remains until April. Abundant. Inhabits, *exclusively*, bare level meadows and open commons. Eminently gregarious while here.

115. *Pinicola canadensis*, (Briss.,) Cab.—Pine Grosbeak. An exceedingly rare and probably only accidental visitant in severe winters.

116. *Carpodacus purpureus*, (Gm.,) Gray.—Purple Finch. Winter resident; very abundant; eminently gregarious. Arrives early in October, and remains until May. Stragglers are seen through the greater part of that month, but the majority depart as soon as the leaves are fully expanded. High, open woods; feeding chiefly (entirely in spring) on tender young buds. Are in full song before they take their departure.

117. *Chrysomitris tristis*, (Linn.,) Bon.—Gold Finch. "Briar Bird." Permanent resident. Exceedingly abundant. Breeds in numbers throughout the city, building in the crotches of poplars and maples. In winter gregarious, collecting in very large flocks about the 25th of September, and continuing so until May. Is in dull plumage as long as it remains in flocks.

118. *Chrysomitris pinus*, (Wils.,) Bon.—Pine Finch. Winter resident; rather uncommon; always found in flocks, frequently associating with *C. tristis*. Remains until May.

119. *Ægiothus linaria*, (Lin.,) Cab.—Common Red-poll Linnet. Rare, perhaps only accidental visitant in severe winters, when it appears in restless flocks of greater or less extent.

[The two species of Cross-bills—*Curvirostra americana* and *leucoptera*—undoubtedly sometimes make their appearance in severe winters, though we have not been able to ascertain the fact with certainty.]

120. *Plectrophanes nivalis*, Meyer.—Snow Bunting. Rare visitant in the depth of winter.

[*P. lapponicus* may very possibly visit us occasionally.]

121. *Passerculus savanna*, (Wils.,) Bon.—Savanna Sparrow. Chiefly spring and autumn visitant; a few doubtless winter in secluded situations; none breed. Very numerous on low, moist meadows and watery savannas from March 15 to first week in May, and from October 10 to November 10. Shy and retiring; associate in companies; keep always on the ground. Are in full song before they depart.

122. *Pooecetes gramineus*, (Gm.,) Bd.—Bay-winged Bunting. Grass Finch. Resident all the year; very numerous in spring and autumn, less so in summer and winter. Frequent high dry fields, road sides, &c.

123. *Coturniculus passerinus*, (Wils.,) Bon.—Yellow-winged Sparrow. Summer resident; abundant. Arrives April 25; remains until October 15. Inhabits exclusively meadows and fields, keeping closely concealed in the grass. Usually solitary.

124. *Coturniculus henslowi*, (Aud.,) Bon.—Henslow's Bunting. Summer resident; exceedingly rare. (But one specimen known to have been obtained.)

125. *Zonotrichia leucophrys*, (Forst.,) Sw.—White-crowned Sparrow. Winter resident. Usually rare, but more plenty at irregular intervals; (e. g., in spring of 1861.) Remains until second week in May.)

126. *Zonotrichia albicollis*, (Gm.,) Bon.—White-throated Sparrow. Chiefly spring and autumn visitants, but numbers spend the winter in sheltered localities. Arrives early in October, and is exceedingly abundant during that month; becomes very numerous again the 1st of April and continues so until May 12. Mostly gregarious; frequent chiefly briar patches, hedges, roadsides, &c., in fall and winter, but in spring found on the ground in open woods. Sings both in fall and spring.

127. *Junco hyemalis*, (Linn.,) Sclat.—Snow Bird. Winter resident. Arrive in fall, October 10 or 12; soon become very numerous, and continue so until 15th of April. Stragglers seen till May. Found everywhere; in pleasant weather keep close in thickets, ravines, &c., but in severe weather approach farm-houses and scatter through the city. Gregarious; in full song before they leave.

128. *Spizella monticola*, (Gm.,) Bd.—Tree Sparrow. The most abundant winter sparrow except *Melospiza melodia*. Arrives 1st of November and leaves 1st of April; shy and retiring; chiefly gregarious. Found in thickets, briar patches, &c. Sings all through the winter.

129. *Spizella socialis*, (Wils.,) Bon.—Chipping Sparrow. Summer resident. Semi-domesticated, like *Troglodytes aedon;* breeds in orchards, gardens, shrubbery, about porches, &c. Especially fond of building the nest in small cedar bushes. March 10 to October 10.

130. *Spizella pusilla*, (Wils.,) Bon.—Field Sparrow. Resident all the year; especially abundant in spring; less so in summer and autumn; only found in secluded situations in winter. In full song in spring and occasionally sings in fall. Gregarious, except during the breeding season. Breeds in small, isolated bushes in fields, near the ground. (*Albino* obtained.)

131. *Melospiza melodia*, (Wils.,) Bd.—Song Sparrow. Permanent

resident. Excessively abundant, especially in winter, when it associates in large companies in briar patches and along tangled borders of streams.

132. *Melospiza palustris*, (Wils.,) Bd.—Swamp Sparrow.—Chiefly spring and autumn visitant; arrive in spring last week in April; become abundant in the fall, second week in October; very secluded and retiring in habits. Gregarious in fall.

[*Melospiza lincolni* is, in all probability, an inhabitant of the District, though we have never succeeded in detecting it.]

133. *Passerella iliaca*, (Merrem,) Sw.—Fox-colored Sparrow. Chiefly spring and autumn visitant, though some spend the winter in sheltered situations. Abundant from November 1 to 30, and from March 1 to 30. Eminently gregarious; inhabits thickets and the densest briar patches and laurel brakes. Sing just before departing; none breed.

134. *Euspiza americana*, (Gm.,) Bon.—Black-throated Bunting. Summer resident. Arrives May 1; leaves towards the end of September. Inhabits open fields and meadows. Abundant, especially in the spring.

135. *Guiraca ludoviciana*, (Linn.,) Sw.—Rose-breasted Grosbeak. Rare. Summer visitant; seen only at intervals. Found in high, open woods; generally in small companies. Shy and difficult to procure.

136. *Guiraca cœrulea*, (Linn.,) Sw.—Blue Grosbeak. Summer resident. Rather rare. Breeds in much the same places as does *Cardinalis virginianus;* at other times found in more open situations, orchards, sparse woods, &c. Arrives first week in May; departs about middle of September.

137. *Cyanospiza cyanea*, (Linn.,) Bd.—Indigo Bird. "Little Blue Bird." Summer resident. Common. Arrives 1st of May; remains until second week in September. About orchards, edges of woods, meadows, &c.

138. *Cardinalis virginianus*, Bon.—Cardinal Grosbeak. "Red Bird." Resident all the year. Abundant, but always shy and difficult to procure. Frequents only the thickest briar patches. Moults from middle of July till October.

139. *Pipilo erythrophthalmus*, (Linn.,) Vieill.—Towhe Bunting. "Marsh Robin." Chiefly spring and autumn visitant; a few breed. Very abundant from April 25 to May 10, and from first to third week in October. Thickets, laurel brakes, &c.; partially gregarious.

140. *Dolichonyx oryzivorous*, (Linn.,) Sw.—Bob-o'-link. "Reed Bird." Spring and autumn visitant. In spring distributed abundantly about orchards and meadows, even at that season generally in flocks, from May 1 to 15; in autumn frequent in immense flocks the tracts of *Zizania aquatica*, along the river; also cornfields, &c., from August 20 to October.

141. *Molothrus pecoris*, (Gm.,) Sw.—Cowpen Bird. "Cow Bird." Summer resident. Not very common. Arrives second week in March; remains till October.

142. *Agelaius phœniceus*, (Linn.,) Vieill.—Red-winged Black Bird. Resident nearly all the year; more abundant in spring and fall, especially the latter. Breed. Commence to flock over the tracts of

Zizania aquatica and the neighboring cornfields the first week in August. Arrive in small flocks early in March.

143. *Sturnella magna*, (Linn.,) Sw.—Meadow Lark. Field Lark. Resident all the year. Abundant. Collect in flocks, sometimes of great extent, and then are very shy. Old fields, meadows, &c.

144. *Icterus baltimore*, (Linn.,) Daudin.—Baltimore Oriole. Chiefly spring and autumn visitant, though many breed. Arrives the first week in May, and remains until latter part of September. Orchards; high, open woods.

145. *Icterus spurius*, (Linn.,) Bon.—Orchard Oriole. Summer resident. Not uncommon. Arrives first week in May; remains till latter part of September. Orchards, meadows, and high, open woods.

146. *Scolecophagus ferrugineus*, (Gm.,) Sw.—Rusty Grackle. "Black Bird." Winter resident. Abundant. Strictly gregarious. Arrives third week in October; remains until April. Swampy localities; also ploughed fields, &c.

147. *Quiscalus versicolor*, (Linn.,) Vieill.—Purple Grackle. "Crow Black Bird." Summer resident. Abundant, but more particularly so in spring and fall. Arrives about March 15; departs late in October.

148. *Corvus americanus*, Aud.—Common Crow. Resident all the year. Very abundant. Found everywhere. Gregarious in winter. Less abundant during the breeding season.

149. *Corvus ossifragus*, Wils.—Fish Crow. Resident all the year. Abundant. Less wary and suspicious than the preceding, and more confined to the borders of the rivers. Confounded with the preceding generally.

150. *Cyanura cristata*, (Linn.,) Sw.—Blue Jay. "Jay Bird." Resident all the year. Abundant, especially in fall and winter, when it is partially gregarious. Found everywhere.

151. *Ectopistes migratoria*, (Linn.,) Sw.—Wild Pigeon. Make their appearance in flocks at irregular intervals throughout the fall, winter, and early spring months.

152. *Zenaidura carolinensis*, (Linn.,) Bon.—Carolina Turtle Dove. "Dove." Permanent resident. Not very abundant. Sometimes collect in large flocks in the fall, when they frequent cornfields, &c.

153. *Chamæpelia passerina*, (Linn.,) Sw.—Ground Dove. An entirely accidental visitor from the south.—(One specimen obtained, now in museum S. I.)

154. *Meleagris gallopavo*, Linn.—Wild Turkey. Regularly seen in the markets all through the winter, though not often found in the immediate vicinity of the city. Remains all the year in the neighboring districts.

155. *Bonasa umbellus*, (Linn.,) Stephens. Ruffed Grouse. "Pheasant." Resident all the year. Apparently not uncommon, but frequent mostly impenetrable laurel brakes, &c., and are difficult to procure.

156. *Ortyx virginianus*, (Linn.,) Bon.—American Partridge. "Partridge." Resident all the year. Still abundant in the immediate vicinity of the city during the late fall and winter months.

157. *Grus canadensis*, (Linn.,) Temm.—Sand-hill Crane. Exceedingly rare; perhaps only accidental. (Specimen obtained.)

158. *Garzetta candidissima*, (Jacq.,) Bon.—Snowy Heron. Not uncommon about the marshes of the Potomac in early fall.

159. *Herodias egretta*, (Gm.,) Gray.—White Egret. Occasionally seen along the river in the late summer and early fall months.

160. *Ardea herodias*, Linn.—Great Blue Heron. "Blue Crane." Found at intervals during the summer and early autumn along the marshes bordering the river.

161. *Florida cærulea*, (Linn.,) Bd.—Little Blue Heron. Rare, perhaps only accidental, towards the end of summer. (Specimen obtained.)

162. *Ardetta exilis*, (Gm.,) Gray.—Least Bittern. Summer resident; rather uncommon. Arrives early in May; departs late in September. Found chiefly in the *Zizania aquatica* marshes.

163. *Botaurus lentiginosus*, Steph.—Bittern. "Indian Hen." "Sage Hen." Resident all the year. Common. Only heron that winters here.

164. *Butorides virescens*, (Linn.,) Bon.—Green Heron. "Fly-up-the-creek." Summer resident. Most abundant of the herons. Arrives 1st of May; remains until middle of September. Numerous about Rock creek and the marshes and creeks of the Potomac.

165. *Nyctiardea gardeni*, (Gm.,) Bd.—Night Heron. Rare; seen occasionally during the latter part of summer.

166. *Charadrius virginicus*, Borck.—Golden Plover. "Bull-head Plover." Spring and autumn visitant. Passes quickly through in early spring; is more numerous in autumn, during latter part of October and whole of November, about fields, ploughed land, &c.

167. *Ægialitis (Oxyechus) vociferus*, (Linn.,) Cass.—Killdeer Plover. "Killdee." Resident all the year, or nearly so. Most numerous early in spring and late in autumn; generally seen in flocks, on meadows, commons, ploughed lands, &c.

[*Ægialitis semipalmatus* is undoubtedly an inhabitant of the District.]

168. *Philohela minor*, (Gm.,) Gray.—Woodcock. Resident all the year. Common. Frequent chiefly "Woodcock brakes" and moist cornfields; and in early spring low woods and thickets.

169. *Gallinago wilsonii*, (Temm.,) Bon.—Wilson's Snipe. "English" or "Jack" Snipe. Spring and autumn visitants. Abundant. Pass through early in the spring and return in the fall the first week in September, and remain about two weeks. In flocks in the fall.

[*Macrorhamphus griseus*, though we have not detected it, is doubtless an inhabitant of the District.]

[*Micropalama himantopus* may very possibly be hereafter detected.]

170. *Actodromas maculata*, (Vieill.,) Cass.—Pectoral Sandpiper. "Grass Snipe." Spring and autumn visitant. Rarely seen in spring. Not uncommon in autumn from September 25 to November. Low, moist, grassy meadows, boggy commons, &c. Seen singly as often as in flocks.

171. *Actodromas minutilla*, (Vieill.,) Coues.—Least Sandpiper.

Spring and autumn visitant. In spring from May 1 to 15; in fall from August 25 to October. In habits very similar to preceding.

172. *Ereunetes pusillus*, (Linn.,) Cass.—Semipalmated Sandpiper. Rare; perhaps accidental; occasionally met with in spring and fall along the banks of the river. [Possibly a second species, (*Ereunetes minor*, Gundl.)]

173. *Symphemia semipalmata*, (Gm.,) Hartl.—Willet. Rare; spring and autumn visitant.

174. *Gambetta melanoleuca*, (Gm.,) Bon.—Greater Tell-tale Tatler. "Yellow-shanks Plover." Spring and autumn visitant. Common. In spring, from May 1 to 15; in autumn, middle of September to November. Generally seen singly or two or three together. Banks of the rivers, boggy meadows, commons intersected with pools, &c.

175. *Gambetta flavipes*, (Gm.,) Bon.—Lesser Tell-tale Tatler. "Yellow-shanks Plover." Identical in times of appearance and in habits with preceding.

176. *Rhyacophilus solitarius*, Wils.—Solitary Tatler. Spring and autumn visitant; very abundant, especially in spring. May 1 to 15, and August 25 to October 15. Very familiar and unsuspicious; decidedly gregarious, both in spring and fall. Frequents ditches and puddles, in low, boggy commons, &c.

177. *Tringoides macularius*, (Linn.,) Gray.—Spotted Sandpiper. "Sand Snipe." Summer resident; very abundant in spring. The only sandpiper that breeds. Arrives April 20 and remains through greater part of September. Found chiefly on Rock creek and banks of the river.

178. *Actiturus bartramius*, (Wils.,) Bon.—Bartram's Tatler. Grass Plover. Field Plover. Summer resident; rare. Found altogether on high, open fields and ploughed lands.

179. *Numenius longirostris*, Wils.—Long-billed Curlew. Not uncommon. Spring and autumn visitant; remaining a very short time at each season. In fall, about the middle of September. Found in places similar to those which the Yellow-legs frequent.

180. *Rallus elegans*, Aud.—Fresh-water Marsh-hen. "King Ortolan." Found sparingly in early autumn in the marshes along the rivers, with the P. carolina.

181. *Rallus virginianus*, (Linn.)—Virginia Rail. Spring and autumn visitant. Very rare in the spring, and not abundant in the fall. Arrives in fall the last week in August; departs about the same time with the P. carolina.

182. *Porzana carolina*, Vieill.—Common Rail. Sora. Ortolan. Spring and autumn visitant. Rare in spring, but very abundant in fall from the last week in August until the first frost. Found exclusively in the marshes bordering the Potomac and Eastern Branch.

[*Porzana noveboracensis*, though not detected, is undoubtedly an inhabitant of the District.]

183. *Porzana jamaicensis*.—Black Rail. Very rare, perhaps only accidental, during the early fall. (Specimen seen by ourselves September, 1861.)

184. *Fulica americana*, Gm.—Coot. "Crow Duck." Spring and

autumn visitant; passing through early in the spring, and returning in the fall about the 1st of October. Very common in the fall.

185. *Cygnus americanus*, Sharpless.—American Swan. Winter resident. Not common. Seen sometimes on the river, and frequently exposed for sale in the market.

186. *Bernicla canadensis*, (Linn.,) Boie.—Canada Goose. Wild Goose. Winter resident. Common, but seen most frequently in the air, flying over. Arrive in fall just before the first approach of severe weather. Found in market through the winter.

187. *Anas boschas*, (Linn.)—Mallard. Very abundant winter resident. Found upon the Potomac and Anacostia rivers, and (more rarely) upon creeks and ponds.

188. *Anas obscura*, Gm.—Dusky Mallard. Black Mallard. Not rare. Habits same as those of preceding.

189. *Dafila acuta*, (Linn.,) Jenyns.—Pintail Duck. Sprig-tail. Winter resident. Common. Found mostly along the margins of the rivers, and sometimes inland. Arrive about the first of October.

190. *Nettion carolinensis*, (Gm.,) Baird.—Green-winged Teal. Winter resident. Abundant. Found chiefly along the marshes of the Potomac and Anacostia. Arrives sooner than most of the ducks, about the middle of September.

191. *Querquedula discors*, (Linn.,) Steph.—Blue-winged Teal. Winter resident. The most abundant of the ducks. Habits much as those of preceding.

192. *Chaulelasmus streperus*, (Linn.,) Gray.—Gadwall. Winter resident. Habits similar to those of the Mallard, with which it is often found associated, but it is less numerous.

193. *Mareca americana*, (Gm.,) Stephens.—Widgeon. Winter resident. Arrives in the fall about the first of October, and departs in spring during the month of April. Very abundant and not so difficult of approach as are most of the ducks.

194. *Aix sponsa*, (Linn.,) Boie.—Wood-duck. Summer Duck. Permanent resident; but more abundant in winter, being seldom seen in summer. Not very abundant at any time.

195. *Fulix marila*, (Linn.,) Bd.—Greater Black-head Duck. Winter resident. Not very abundant. Often exposed for sale in market, but not much esteemed for food.

196. *Fulix affinis*, (Forst.,) Bd.—Lesser Black-head Duck. Winter resident. Same as preceding.

197. *Fulix collaris*, (Donovan,) Baird.—Ring-neck Duck. Winter resident. Rare. Arrives in fall about the last week in September.

198. *Aythya americana*, (Eyton,) Bon.—Red-head duck. Winter resident. Very abundant. A common market duck, and frequently offered for sale as the canvas back. Found upon the "flats" of the rivers, and occasionally on inland marshes.

199. *Aythya vallisneria*, (Wils.,) Bon.—Canvas-back duck. Winter resident. At times exceedingly abundant. Highly prized by sportsmen and epicures. Habits much those of the preceding.

200. *Bucephala americana*, (Bon.,) Baird.—Golden-eye duck. Winter resident. Rather abundant. Frequently seen in the market.

201. *Bucephala albeola*, (Linn.,) Baird.—Buffel-headed duck; "Butter-ball." Winter resident. More common than preceding. Arrive in fall, about the middle of September; leave in spring, the second week in April.

202. *Harelda glacialis*, (Linn.,) Leach.—Long-tailed duck.

203. *Melanetta velvetina*, (Cass.,) Baird.—Velvet duck.

204. *Pelionetta perspicillata*, (Linn.,) Kaup.—Surf duck.

205. *Oidemia americana*, Swainson.—Scoter duck.

(The four preceding birds do not properly belong to the fauna of the District, being strictly marine birds. They are found at the mouth of the Potomac, and ascend it as far as the salt water reaches. Their appearance in this immediate locality must, however, be considered accidental. They are all to be seen in the market during the winter.)

206. *Erismatura rubida*, (Wils.,) Bon.—Ruddy duck. Winter resident. Abundant. Frequently exposed for sale in the market, but not esteemed for food.

207. *Mergus americanus*, Cassin.—Goosander. "Fishing duck." Winter resident. Not common. More frequently seen on creeks and millponds than on the rivers.

208. *Mergus serrator*, Linn.—Red-breasted merganser. "Fishing duck." Winter resident. Rather more common than the preceding. Found in much the same situations.

209. *Lophodytes cucullatus*, (Linn.,) Reich.—Hooded merganser. Winter resident. Rather rare.

210. *Thalassidroma leachii*, Bon.—Leach's Petrel. Accidental visitor. (Numbers were seen during a storm some years ago.)

211. *Puffinus*, ——? A shearwater, probably *P. obscurus*, has been detected in the District.

212. *Larus smithsonianus*,* Coues.—Herring gull. "Sea gull." Seen over the river through the winter. Not numerous. Exceedingly shy and wary.

213. *Larus delawarensis*, Ord.—Ring-billed gull. Seen about the river during the winter months. More numerous than the preceding.

214. *Chroicocephalus atricilla*, (Linn.,) Lawr.—Laughing gull. Occasionally seen during the late summer and early autumn months.

215. *Chroicocephalus philadelphia*, (Ord.,) Lawr.—Bonaparte's hooded gull. More abundant than the preceding, being quite common. Remains here through the winter.(?)

216. *Sterna aranea*, Wils.—Marsh Tern. Rare; only occasionally seen during the late summer and early fall months, over the marshes bordering the river.

217. *Sterna wilsonii*, Bon.—Wilson's Tern. An occasional visitor during the late summer and early fall months. [*Sterna forsteri* is undoubtedly to be found in the District.]

218. *Sterna frenata*, Gambel.—Least Tern. Not uncommon. Frequently seen over the marshes bordering the Potomac and Eastern Branch in August and September, and more rarely in spring.

219. *Hydrochelidon plumbea*, Wils.—Short-tailed Tern. "Little

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* See Proc. Acad. Nat. Sci., Philadelphia, June, 1862, p. 296.

Sea Gull." Less numerous than preceding, but found in similar localities and at much the same times.

220. *Rhynchops nigra*, Linn.—Black Skimmer. A rare, perhaps accidental, visitor during the summer. (Specimens seen by ourselves September 8, 1858, on the Potomac river.)

221. *Graculus dilophus*, Gray.—Double-crested Cormorant. A specimen has been detected.

222. *Colymbus torquatus*, Brunn.—Great Northern Diver. "Loon." Occasionally seen during the winter.

223. *Podiceps (Pedetaithya) holbolli*, Reinhardt.—Red-necked Grebe. Not uncommon on the Potomac during the winter months.

224. *Podiceps cristatus*, Lath.—Crested Grebe. "Water Witch." Found on the Potomac during the winter months.

225. *Podiceps (Dytes) cornutus*, Lath.—Horned Grebe. Common on Potomac in winter.

226. *Podilymbus podiceps*, (Linn.) Lawr.—"Dipper." "Water Witch." Abundant on the Potomac in winter. (We have not been able to ascertain the precise times of arrival and departure of the five preceding birds.)

The birds included in the preceding catalogue are now presented in sections to show at a glance those which are permanent, or summer, or winter residents, and those which are regular or accidental visitants. It is somewhat difficult to make out such an analytical table, from the fact that of some species undoubtedly to be classed as spring and autumn visitants a few individuals breed or pass the winter in secluded situations, and *vice versa* of those which regularly pass the summer or winter with us, many are more abundant in the spring and fall. We have endeavored to place each species in the class under which it most naturally falls, indicating irregularities of this sort in foot notes.

A.

PERMANENT RESIDENTS.

Cathartes aura.
Falco sparverius.
Accipiter cooperi.
Accipiter fuscus.
Buteo borealis.
Buteo lineatus.
Buteo pennsylvanicus.
Circus hudsonius.
Haliætus leucocephalus.
Scops asio.
Bubo virginianus.
Otus wilsonianus.
Brachyotus cassini.
Syrnium nebulosum.
Picus villosus.
Picus pubescens.
Sphyropicus varius.
Hylatomus pileatus.
Centurus carolinus.
Colaptes auratus.
Turdus migratorius.
Sialia sialis.
Ampelis cedrorum.
Thriothorus ludovicianus.
Certhia americana.
Sitta carolinensis.
Lophophanes bicolor.
Chrysomitris tristis.
Spizella pusilla.
Melospiza melodia.
Cardinalis virginianus.
Agelaius phœniceus.
Sturnella magna.
Corvus americanus.
Corvus ossifragus.
Cyanura cristata.
Zenaidura carolinensis.
Bonasa umbellus.
Meleagris gallopavo.
Ortyx virginianus.
Botaurus lentiginosus.
Ægialitis vociferus.
Philohela minor.
Aix sponsa.

B.

WINTER RESIDENTS.

Falco columbarius.
Aquila canadensis.
Ectopistes migratoria.
Chaulelasmus streperus.
Erismatura rubida.
Bucephala americana.

Anthus ludovicianus.
Regulus satrapa.
Dendroica coronata.
Collyrio borealis.
Anorthura hyemalis.
Sitta canadensis.
Parus atricapillus.
Eremophila cornuta.
Carpodacus purpureus.
Chrysomitris pinus.
Zonotrichia leucophrys.
Junco hyemalis.
Spizella monticola.
Scolecophagus ferrugineus.
Mareca americana.
Fulix marila.
Fulix affinis.
Fulix collaris.
Aythya americana.
Aythya vallisneria.
Cygnus americanus.
Bernicla canadensis.
Anas boschas.
Anas obscura.
Dafila acuta.
Nettion carolinensis.
Querquedula discors.
Bucephala albeola.
Mergus americanus.
Mergus serrator.
Lophodytes cucullatus.
Larus smithsonianus.
Larus delawarensis.
Chroicocephalus philadelphia.
Podiceps holbölli.
Podiceps cristatus.
Podiceps cornutus.
Podilymbus podiceps.

C.

SUMMER RESIDENTS.

Pandion carolinensis.
Coccygus americanus.
Coccygus erythrophthalmus.
Melanerpes erythrocephalus.
Trochilus colubris.
Chætura pelasgia.
Antrostomus vociferus.
Ceryle alcyon.
Tyrannus carolinensis.*
Myiarchus crinitus.
Sayornis fuscus.*
Contopus virens.
Empidonax acadicus.
Turdus mustelinus.
Mniotilta varia.*
Geothlypis trichas.
Icteria viridis.
Seiurus aurocapillus.
Seiurus noveboracensis.
Helmitherus vermivorus.
Dendroica aestiva.
Dendroica pinus.
Dendroica discolor.
Pyranga æstiva.
Hirundo horreorum.
Hirundo lunifrons.*
Hirundo bicolor.*
Cotyle riparia.
Cotyle serripennis.
Progne purpurea.
Vireo olivaceus.
Seiurus ludovicianus.
Vireo flavifrons.
Vireo gilvus.
Mimus polyglottus.
Mimus carolinensis.
Harporhynchus rufus.
Troglodytes ædon.
Cistothorus palustris.
Polioptila cærulea.
Parus carolinensis.
Pooecetes gramineus.
Coturniculus passerinus.
Coturniculus henslowi.
Spizella socialis.
Euspiza americana.
Guiraca ludoviciana.
Guiraca cærulea.
Cyanospiza cyanea.
Molothrus pecoris.
Icterus baltimore.*
Icterus spurius.
Ardea herodias.
Garzetta candissima.
Herodias egretta.
Butorides virescens.
Nyctiardea gardeni.*
Tringoides macularius.*
Actiturus bartramius.

* The greater number go further north.

D.

SPRING AND AUTUMN VISITANTS—MIGRATORY SPECIES.

Chordeiles popetue.
Empidonax traillii.*
Empidonax flaviventris.*
Empidonax minimus.
Turdus pallasii.
Turdus fuscesens.
Turdus swainsonii.
Turdus aliciæ.
Regulus calendula.†
Dendroica virens.
Dendroica canadensis.
Dendroica blackburniæ.
Dendroica castanea.
Dendroica pennsylvanica.
Dendroica striata.
Dendroica maculosa.
Dendroica tigrina.
Dendroica palmarum.
Pipilo erythrophthalmus.*
Dolichonyx oryzivorus.
Quiscalus versicolor.*
Ardetta exilis.*
Charadrius virginicus.
Gallinago wilsonii.
Actodromas maculata.
Actodromas minutilla.
Symphemia semipalmata.

Parula americana.
Oporornis agilis.*
Oporornis formosus.*
Helminthophaga pinus.
Helminthophaga chrysoptera.
Helminthophaga ruficapilla.
Helminthophaga peregrina.
Myiodioctes mitratus.*
Myiodioctes pusillus.*
Myiodioctes canadensis.
Setophaga ruticilla.*
Pyranga rubra.*
Vireo solitarius.*
Passerculus savanna.
Melospiza palustris.
Passerella iliaca.†
Zonotrichia albicollis.†
Gambetta melanoleuca.
Gambetta flavipes.
Rhyacophilus solitarius.
Numenius longirostris.
Rallus elegans.
Rallus virginianus.
Porzana carolina.
Fulica americana.
Sterna frenata.
Hydrochelidon plumbea.

* A few may, in some cases certainly do, breed here.
† A few probably remain through the winter.

E.

ACCIDENTAL OR VERY RARE VISITORS.

Astur atricapillus.*
Nyctea nivea.*
Milvulus ———?
Protonotaria citrea.
Dendroica superciliosa.
Pinicola canadensis.*
Ægiothus linarius.*
Plectrophanes nivalis.*
Chamaepelia passerina.†
Porzana jamaicensis.
Grus canadensis.
Florida cærulea.†
Ereunetes pusillus.
Harelda glacialis.
Melanetta velvetina.
Pelionetta perspicillata.
Oidemia americana.
Thalassidroma Leachii.
Puffinus ———?
Chroicocephalus atricilla.†
Sterna aranea.
Sterna wilsoni.
Rhynchops nigra.†
Graculus dilophus.
Colymbus torquatus.*

* From the north in severe winters.
† From the south towards the end of summer.

F.

SOME SPECIES NOT INCLUDED IN THE LIST, WHICH ARE PROBABLY YET TO BE DETECTED IN THE DISTRICT.

Nauclerus furcatus.
Nyctale acadica.
Dendroica cærulea.
Vireo philadelphicus.
Cistothorus stellaris.
Curvirostra americana.
Curvirostra leucopterus.
Plectrophanes lapponicus.
Melospiza lincolni.
Aegialitis semipalmatus.
Macrorhamphus griseus.
Micropalama himantopus.
Porzana noveboracensis.
Sterna forsteri.
Geothlypis philadelphia.

SUMMARY.

Permanent residents	44
Winter residents	44
Summer residents	59
Regular visitants	54
Accidental visitants	25
Total	226

PRIZE QUESTIONS OF SCIENTIFIC SOCIETIES.

In accordance with a request from Utrecht, we give the following translation of the proceedings of several of the Holland societies, relative to prize questions proposed by these establishments for free competition to the citizens of all nations. We regret that we have not received a full set of these proceedings, but hope to present in a future report the remainder of the series.—*Sec. Sm. Inst.*

EXTRACT FROM THE PROCEEDINGS OF THE HOLLAND SOCIETY OF SCIENCE AT HARLEM, FOR THE YEAR 1856.

The society held its 104th annual session on the 17th of May, 1856. Since its last session it has received: 1st. A memoir, written in German, and having the epigraph, "*Nec aspera terrent.*" This memoir was written as a reply to the following question:

"A history is requested of the development of the *Petromyzon fluviatilis*, illustrated by the necessary figures, and compared with that of other fishes, according to the researches of Von Baer, Rathke, and C. Vogt."

This memoir does not, in fact, contain the history of the *Petromyzon fluviatilis*, but that of *P. Planeri*. However, this latter species is so near akin to the other, that the memoir substantially answers the purpose proposed for it by the society, and the gold medal is therefore awarded to the author, Dr. Max Sigmund Schultze, doctor of medicine and philosophy, and professor extraordinary of anatomy in the University of Halle.

The society has received: 2dly. A memoir, written in German, bearing the epigraph, "*Amicus Plato, amicus Socrates, sed magis amica veritas,*" and relative to the following question published by the society:

"The illustrious director of the University of Pulkowa, the Astronomer F. G. W. Struve, published in 1847 his well-known book, entitled "STUDIES IN STELLAR ASTRONOMY." In that work he communicates, as the result of his observations, some very remarkable details concerning the structure of the universe and the transparency of space. The London Astronomical Society, in its report of the twenty-eighth general meeting, gave the support of its authority to Struve's results, while, on the other hand, the celebrated astronomer J. F. Encke, in No. 622 of the *Astronomische Nachrichten*, considers them hypothetical and without foundation. The society, consequently, desires that a profound and scrupulous examination may

decide what the present state of astronomy permits us to consider well established or very probable, as to the structure of the universe.''

The society awarded its gold medal and the additional prize of 150 florins to the learned author of this work, Dr. Johann Heinrich Mädler, professor of astronomy and director of the observatory at Dorpat.

The society has seen fit to repeat the following questions, and requires them to be answered before the first of January, 1858:

1. Is there a well-authenticated connexion between the hypertrophies of the spleen and a morbid state of the blood, characterized by an abundance of white globules?

The society desires that this question should be cleared up by anatomico-pathologic researches and by clinical observations.

2. The society calls for a comparative description of the system of the lymphatic and chyliferous vessels in fishes. It requires: 1st, that there be especially an examination of these vessels and of those of the sanguineous system; and, 2dly, that the observations of Föhman and Treviranus be repeated and discussed.

The society requires that at least three very different families be compared, and that the entire system of these two vessels be described as completely as possible, as regards one species of fish; the whole to be accompanied by requisite figures.

3. The society requests that, by a physiological, experimental, and comparative examination, an endeavor be made to establish the nature of the function of the peculiar substance secreted in the great intestine of many of the mammalia. It desires that this examination include, at least, the carnivora, the ongules, and the rongeurs.

4. Some savans maintain that a portion of an electric current, passing through an electrolyte, traverses it without exercising any chemical action. The society desires that this opinion be subjected to a rigorous experimental examination. If it be verified, the society requests that then there shall be ascertained, for at least six different electrolytes, what the numerical relation is which exists between the part of the current which decomposes the electrolyte and the part for which the electrolyte appears to be endowed with a conducting power similar to that of the metals.

5. The recent experiments of Faraday, made with long wire of metal covered with gutta-percha and immersed in water, have demonstrated that the velocity of electricity in metallic or other conductors is not always the same. The society desires that this velocity, in connexion with the circumstances which modify it, be determined anew by exact experiments.

6. The existence of what is called the catalytic force, by which heretofore we have sought to explain many phenomena becoming more and more doubtful, the society desires a rigorous examination of the phenomena which some savans still attribute to that force.

7. In what part of the human body is sugar produced, and when and in what manner does the production take place?

8. There still remains some uncertainty as to the manner in which the algæ (popularly known as sea-weeds) reproduce their species. The society desires that new researches be made upon this subject, and that the development from the embryo to the perfect plant, of three species at least, belonging to widely differing families of these plants, be observed, described, and, if necessary, illustrated by figures.

9. What are the characteristics, deducible from fossils or other circumstances, which enable us to decide with certainty whether alluvial strata have been deposited in fresh water, in water more or less brackish, or in the sea?

The society desires that the truth of these characteristics should be confirmed by the examination of different beds of alluvial deposit of the origin of which there is no doubt.

10. What conclusion can be drawn, from the geological constitution of the land, as to the extent, &c., of the old embouchure of the Rhine, near Katwijk, such as it existed before it was closed; whether by a violent cataclysm or by progressive encroachments of the land? What are the evident vestiges that this embouchure has left?

11. All that is known about the fossils of the Dutch East Indian archipelago is limited to a few plants of the island of Java, which have been examined and described by Professor Göppert, of Breslau; and to the tertiary molluscs of that island, which have been deposited in the Dutch Royal Museum at Leyden. The island of Java is the only one of that archipelago of which the geological formation is somewhat known.

The society desires that similar researches be extended to another of the populated islands of that archipelago, and that the organic remains, especially those of the oldest strata that are to be found there, be examined and described, so that the geological period of the formation of that island may be determined.

The society would be well pleased to receive the fossils of the strata of that island, not merely for the sake of the augmentation of its collection, but also for the sake of comparing them with the accompanying descriptions and figures. It will award to the author such a sum as will be in proportion to the importance of his memoir and its accompaniments, a sum which, indeed, it would not hesitate to pay for a collection of those fossils, unaccompanied by either description or figures.

The society has this year proposed the following questions, and requests the answers to them before the 1st of January, 1857:

1. According to the researches published in 1848 by the American astronomer, Professor Peirce, the movement observed in the planet Uranus would be perfectly explained by the intervention of the planet Neptune, if we suppose the latter to have a mass of $\frac{1}{20000}$th that of the sun, while the perturbation observed in the movement of Uranus, which led to the discovery of Neptune, could not be completely attributed to the sole action of the latter, unless it have $\frac{1}{14494}$th of the mass of the sun, as appears to result from the labors of O. Struve.

It seems that except Professor Peirce no astronomer has attended to this important inquiry, while the correctness of the result obtained by O. Struve is strongly corroborated by his subsequent researches, contributed to the "*Physico-Mathematical Bulletin of the Academy of St. Petersburg*," vol. 9, p. 125.

The society, consequently, desires the calculations of Professor Peirce to be repeated, and also that the existing observations upon Uranus and Neptune should be subjected to a strict examination, with a view to determining whether the existence of Neptune can be the cause of that perturbation in the motion of Uranus which hitherto has not been accounted for.

2. The comet which was discovered on the 24th of July, 1852, by Westphal, at Gottingen, is calculated by Sonntag and Marth to describe its orbit around the sun in a period of about 60 years; a fact which renders that celestial body worthy of a rigorous examination.

The society will award its gold medal to the astronomer who, from existing observations and by the most perfect method, shall deduce the elements of the orbit of this comet.

3. In order to calculate the action of the wind upon the sails of vessels and windmills, and to judge of its meteorological effect, there should be a thorough comprehension of the connexion between the pressure exerted by the wind upon a given area and the velocity of that agent. We therefore call for well-conducted experiments from which there shall result an exact determination of the relation between the velocity of the wind and the pressure which it exerts in the right line of its direction. The society requires that the experiments extend to a velocity of at least 20 metres per second.

4. Experiments which were made in England by order of the British government upon the resisting power of the iron employed in bridges and other railroad works showed that the bars bend more perceptibly under a moving than under a stationary load. The society requests an analytic theory of the increase of that deflection, such theory including a consideration of the weight of the load upon the bars as well as the weight of the bars themselves; and that the deflection thus theoretically ascertained be compared with the results of actual experiment.

5. For some time past, and especially since so many geologists have adopted the upheaval system of Elie de Beaumont, frequent attempts have been made to classify the Plutonic rocks according to their age. Charles d'Orbigny has recently bestowed attention upon this subject, and has published a sketch, or outline, of a classification. Still more recent observations have thrown so much light upon the subject, that it is now possible, as regards a great number of those Plutonic rocks, to determine the relative epoch of their appearance on the surface of the globe. The society therefore requests a geognostic classification of Plutonic rocks, according to the epochs of their appearance as integral portions of the crust of our globe.

6. The society requests a description and a geological chart of Dutch Guiana. It is desired that especial attention be bestowed upon the organic fossils to be found in that country; that the

most interesting objects be described and figured, and that, as far as possible, the most characteristic specimens be sent home to the society. Geologists who devote themselves to this investigation should not neglect the rounded stones which are the detritus of rocks frequently inaccessible. Their composition, and the fossils which they contain, should form a principal object of the researches.

7. The society, being persuaded that researches as to the origin, the nature, and the increase of the deltas of great rivers are calculated to lead to interesting results, requests that a delta at the mouth of some one of the great European rivers be exactly described; that both its horizontal and vertical extent be measured; and that the materials of which it consists, as well as the manner in which these materials are arranged, be described and their origin determined. The society desires that the description shall contain all the details necessary to giving a clear idea of the form, the dimensions, the composition, and the arrangement of the materials of the delta, and an accurate account of its origin.

8. The society desires a monograph with figures of fossil birds.

9. What are the changes which compression makes in crystals, as to their qualities as conductors of heat and electricity and their refracting power? New researches are required upon these points.

10. When the magneto-electric apparatus is in action, heat is developed not only in the soft iron which alternately receives and loses the magnetic state, but also, through the medium of the electric current, in the helix of the conductor, and, perhaps, in other parts of the apparatus. The society requests an examination, both theoretical and experimental, into the relation which exists between the heat developed and the motion of the various parts of the apparatus from which this heat results.

11. It is known that in Carniola and other countries animals are found in grottoes where the light never enters, and where sight is a useless sense. The society requests a rigid examination of at least two species of these blind animals, and a clear exposition, by both anatomical description and figures, of what effect is produced by this blindness, especially upon the cerebral and other parts closely connected with the organ of sight.

12. Is it possible to obtain by a chemical process from certain kinds of peat substances which it is impossible, or exceedingly difficult, to obtain from other vegetable materials? If this is the case, what are the substances, what their chemical qualities, and what is the process?

13. The formation of hail is by no means fully understood; we require the true theory of that phenomenon founded both upon new observations and upon the results of observations already known.

14. When a compound body is traversed by an electric current it frequently occurs that particles from one of the electrodes are transferred to the other. Endeavors have recently been made to utilize this phenomenon, for the purpose of removing from the human body to an exterior electrode certain deleterious matters, such as lead, mercury, &c. The society requests further researches upon this sub-

ject; they must be exact and decisive; and may relate to man, to the inferior animals, or to both.

EXTRACT FROM THE PROCEEDINGS OF THE HOLLAND SOCIETY OF SCIENCE, AT HARLEM, FOR THE YEAR 1858.

The society held its 106th annual session on the 22d of May, 1858. Since its last session it had received—

1. A memoir, written in Dutch, bearing the epigraph from Cicero de Divin, *Observatio diuturna notandis rebus fecit artem, Daily observation creates the art of comprehending and describing things*, and having for its subject the following question:

"It is known that the best Peruvian barks, namely, those which yield the greatest amount of quinine, are so rapidly diminishing as to give reason to fear that they will be altogether exhausted. It is of urgent necessity, therefore, to examine other barks considered febrifuges, containing little or no quinine, but much cinchonine, and to ascertain to what extent the latter base is fitted to replace the former. The society, therefore, requests therapeutic studies to be made of cinchonine and its compounds."

In 1857 the society determined that this memoir could not be crowned, but should be passed over to the competition of 1858, in order that the secretary might have an opportunity to make the author aware of what was wanting in his work, and thus enable him to perfect it and present it anew.

The society decided that the memoir, thus revised and completed by the author, deserved to be crowned. The author of the memoir thus accepted is P. J. Hollman, M. D., surgeon, &c., of Edam, North Holland.

The society received—

2. A written memoir, having for its epigraph the following sentence from Berzelius' Treatise on Chemistry, vol. v: "The mysterious action which we attribute to a peculiar force, but probably of an electric nature, and what we call catalytic force."

The society awarded the gold medal to the author of this memoir, Dr. T. L. Phipson, of Paris.

The society received—

3. A memoir, written in French, and sent from Toula, in Russia, and entitled "An attempt to investigate the cause of luminous and calorific phenomena, exhibited by the electric current in a vacuum containing alcoholic vapor."

4. A memoir, written in French, and sent from Montpelier, "On the former existence of perforating molluscs, especially the tubicolate-conchifera molluscs of Lamarck."

5. A memoir, received from Paris, written in French, and entitled "A memoir on experiments tending to show the resistance of compressed air moving within pipes." The society decided that memoirs 3, 4, and 5 include many important observations, but do not

seem to be sufficiently complete to be placed in the number of those which it accepts for publication.

The society thinks fit to repeat the following twelve questions, and it requires answers to them before the 1st of January, 1860:

1. For some years past the Siphonifers have been objects of the learned researches of L. Leuckart, Gegenbaur, Vogt, and Kölliker, and the opinion has prevailed that they should be regarded as colonies of animals. The society requests a critical examination of all that has reference to this class of animals, such examination to be founded upon new researches; and, as an appendix to it, the society requires a plan of classification of the Siphonifers indicative of the relations existing between these animals and other invertebrates.

2. What general results are to be deduced from observations on the development of articulated animals and molluscs in the egg when compared with what is known of the embryology of vertebrated animals?

3. The society requests—1st, an exact description, founded upon microscopic observation, of the compound stomach of ruminating animals, and of the various compartments found in them, illustrated by requisite figures; 2dly, a chemical examination of the fluids contained in the different compartments of these organs at different periods of the process of digestion, and of their action upon aliments by experiments on artificial digestion; and, 3dly, a physiological explication, founded upon these examinations and experiments, of the functions of the various compartments, and of the peculiar structure which enable them to digest, and, perhaps, partially to absorb, a portion of the constituent principles of nourishment.

4. The researches of Slarber, Boddaert, and others, have proved that the shores of Lower Zealand abound in molluscs and rayed animals of species which exist rarely or not at all on shores bounded by sandy beaches. The society desires these shores to be further explored with reference to the fact in question, that the researches be made by the aid of dredges, and that any new or imperfectly known animals thus found may be described and figured.

5. The salts which result from the combination of an electro-positive metallic chloride with an electro-negative chloride are not as yet well known. The society desires new researches upon these interesting compounds.

6. The society requires new researches upon the development of electricity by the friction of liquids upon solids. It especially desires a repetition of the experiments of Faraday with steam at considerable pressures, with a view to ascertaining if there are not some exceptions to the rules laid down by that illustrious *savant*. The society also desires a decision of the question whether the electricity which is frequently developed at the moment when the spheroidal state ceases is due solely to the friction, and whether the greater portion of the electricity obtained when experimenting with solutions should be attributed to the frictions of the liquid molecules against the solid portions deposited by the solution.

7. The electric light which is developed in a vacuum by means, under certain conditions, of Ruhmkorff's apparatus, exhibits alternately, bright and dark bands, which are not yet sufficiently accounted for. The society requires a precise explanation of the causes of this phenomenon.

8. Not only by the direct action of light upon the organs of sight, but also by various action upon the nerves connected with those organs, luminous appearances are produced, even when no light enters the eye itself. The society requires a minute examination of every thing connected with these phenomena, with a view to determining, among other things, whether the appearances can produce secondary images, and if so, what relation do those images bear to the primary phenomenon.

9. The researches of Göppert have shown that all or almost all beds of coal have been formed on the spot or near the spot where they are found. Nevertheless, it is not well known how this has occurred; it still remains to be determined whether they were formed in the sea, in fresh water, or upon dry land, or whether some have been formed under one of these circumstances and some under another. Nor is it more precisely known to what extent we may compare the formation of pit coal with that of peat.

The society requires researches, founded upon a personal examination of different coal beds and peat pits of different kinds, which shall conduce to the *most complete possible* solution of these questions.

10. The society asks exact researches relative to the means by which the mammiferæ and the molluscs are protected from the effects of the great difference of pressure to which they are subject as they descend from the surface of the sea to its successive depths.

11. The most recent researches have proved that the spermatozoides penetrate into the egg. The society requires that observations with reference to this be made upon various mammiferæ, and that the account of these observations be accompanied by the necessary figures.

12. Messrs. Chapuis and Candèze have performed a useful work in publishing, in volume 8 of the Liege Memoirs, a catalogue of the larvæ of the Coleoptera. The society would be glad to receive a memoir containing a similar catalogue of the larvæ of the Neuroptera.

The society has this year proposed the following questions, and requires replies to them before the first of January, 1860:

1. The society requests new researches as to the development and the first phases of life of the *Nematoides*, and especially of those which inhabit the human body.

2. The greater correctness of range obtained by balls and bombs, the centre of gravity of which does not coincide with that of the projectiles, proves the very great importance of a precise understanding of the influence of that eccentricity. The society requests the equation of the trajectory described by the centre of gravity of a sphere

to which a velocity has been communicated in a given direction and which moves in the atmosphere, allowing that its resistance is proportioned to the square of the velocity, and considering the sphere as an inert mass without weight.

3. As chemical affinities undergo remarkable modifications by a change of temperature, and as there is now no difficulty in obtaining heat of great intensity, the society requests a series of researches on affinity at very high temperatures.

4. The conducting power of a metallic wire when traversed for some time by a galvanic current becomes diminished; this effect, if not constant, at least disappears but slowly. The society desires inquiry into the laws which regulate this phenomenon.

5. We require an anatomical description of the bony labyrinth of the organ of hearing, founded on new researches, and applied to the physiology of the ear.

6. We require new experimental researches upon the phenomenon known under the name of fluorescence, making it an especial object to determine what relation exists between this phenomenon and the light produced by substances luminous of themselves, or which become so by friction or by exposure to the sun.

7. The active state of oxygen (ozone) has already engaged the attention of very many scientific men; an analogous state has been supposed to be observed in many other gaseous fluids, but the observations are neither sufficiently numerous nor sufficiently exact. The society desires new researches, with the view to throwing new light upon this phenomenon.

8. The researches of SPENCE BATE have made known the fact that some of the small crustacea construct a nest for themselves. The society invites an exact examination of the nidification in the case of the species already known to practice it, and, if possible, in the case of other crustacea also. The material of which the nests are constructed, as well as the means employed by the crustacea in the construction, should engage the attention of the examiner.

9. Many trees have their stems twisted spirally. We would ask a general physiological explanation of this phenomenon.

10. We want an exact examination of the volcano in the island of Amboyna, (Dutch East Indies,) to determine with precision whether that volcano owes its origin to an upheaving of the ancient strata of the true non-volcanic soil of the island, or whether it is the product of non-coherent matters thrown out by the volcano and accumulated around a crater.

The society recalls the fact that in preceding years it proposed the following questions to be replied to before the first of January, 1859:

1. On passing an electric current through the helix of the electro magnet, the iron does not immediately take the whole magnetic force that the current is capable of giving, and, in like manner, the magnetism of the iron does not suddenly disappear on the breaking of the circuit. The society desires exact experiments for the determi-

nation of the laws of these phenomena; and it also desires a decision of the question whether they are to be attributed to a certain magnetic inertia of the iron, or to the action of currents of induction, or, perchance, to both of these causes at once.

2. We require experimental researches upon the physical and chemical properties of at least two species of vapor, subjected at once to a pressure of at least a hundred atmospheres, and to a very high temperature.

3. Since the establishment of railroads, the construction of oblique arches has very much increased. Nevertheless, the rules for fixing the dimensions of these arches, and of their straight or sloping parts, have not yet reached the degree of perfection arrived at in relation to straight arches. The society, consequently, calls for a mathematical theory of oblique arches whence rules may be deduced for the form and dimensions of these arches for their slopes, and especially for the limit of the inclination allowable to such works.

4. The origin of the sands which extend from the north of Belgium into the Netherlands is not yet well ascertained. The society requests a monograph of those sands; and it especially desires that the rocks of which they are the detritus be indicated with exactitude, if they exist upon the surface of the soil.

5. Some geologists have expressed doubts as to the correctness of the theory of the upheaval of mountains, which they are inclined to attribute to the irregular sinking down of the surface, and the consequent lateral pressure upon the contiguous strata. The society desires an examination of some chain of mountains hitherto regarded as having arisen solely as claimed by the long-received theory and from no other cause, with a view to determine whether its form and elevation must be explained by that cause, or whether they can be sufficiently accounted for by a sinking and its effects in lateral pressure and overlapping.

6. Of what nature is the earth laid bare by the drying up of the lake of Harlem, what is its chemical constitution, and what are we to expect, as regards its fertility, from its chemical constitution and physical properties?

7. The cause of the scratches and furrows to be seen in hard rocks is commonly referred to the existence of vast glaciers in earlier geological periods; the stones carried along by these glaciers having grooved and channelled these rocks. Although as to many places this explanation can scarcely be gainsayed, yet it must be confessed that there are very many other places in which it may be safely affirmed that these effects have had other causes. We want an examination of the characteristics by which such causes may be marked and accurately distinguished from the cause previously mentioned.

8. The North sea has undergone changes from causes common to all seas, as well as from local causes; as, for instance, like that of the change in breadth of *the Strait of Dover*. The society desires a knowledge of these phenomena, with their effects upon the conformation of the coasts, and especially upon the adjoining downs. The society consequently inquires, what changes have been ob-

served in the height of the sea on the coasts of Holland, Belgium, and France? What changes have the currents on those coasts undergone as to their course and their velocity? And what has been the effect of such changes upon the downs in Holland from the mouth of the Meuse to the Helder, and upon those of the islands which lie along the coasts of Friesland and Groningen, especially as to their enlargement in some places and diminution in others.

9. The character of some parts of the organs of hearing are but very imperfectly known. The society calls for exact researches on this subject, so that positive data may be deduced as to the functions of these parts.

10. The society calls for a monograph of the diatomes, both living and fossil, of the island of Java.

11. The application of photography might produce invaluable consequences to the sublime science of astronomy if in a small fraction of a second we could obtain photographic images of celestial as we do of terrestrial bodies. Attempts have been made, but with no satisfactory results, to obtain photographic images of the sun and moon, the failure being especially attributable to the too great length of time required for the production of these images. It seems that no one hitherto has succeeded in photographing the images of planets or of groups of stars. The society, with a view to making photography auxiliary to astronomy, requests an exact and detailed description of a photographic process by which to obtain, in a small fraction of a second, good images of the celestial bodies. The author of the memoir must accompany it with proofs of the process.

12. What, hitherto, have been the results to astronomy of the numerous discoveries of small planets which revolve about the sun between the orbits of Mars and Jupiter? What is their importance, and what their promise as to the future?

13. Although rheostats of different construction have rendered great services to science, these instruments are still far from being equal in precision of results to other scientific instruments. The society, therefore, calls for the description of a rheostat free from the defects of the present construction, with a succinct account of a series of experiments demonstrating the superiority of the new instrument.

14. The maximum of tension at different temperatures has, for some vapors, been determined with great exactness. The Society desires the same to be done for the other vapors, of which that maximum is not as yet well known.

15. Bernouilli's law as to the flow of gas does not agree with recorded experiments. The society requires new experimental researches on this subject.

16. Botany possesses a great many monographs which are justly considered masterpieces; we need only mention those of Richard Brown, Von Martius, Adr. de Jussieu, Grisebach, and others.

The society desiring to promote the progress of botany in that direction, will award its gold medal to the author of a good systematic and organographic monograph of any group of plants as yet but little known.

17. It is of the utmost importance to theoretical chemistry to know the relative intensity of the forces which unite one or two or more equivalents of a substance to one equivalent of another. Admitting that the heat which is disengaged when a combination is effected may serve as the measure of these forces, we yet need experimental research on the quantity of the heat so disengaged when one equivalent of an element combines with one or two or more equivalents of another.

18. What influence has the progress of organic chemistry exercised upon the theory of the composition of inorganic substances? With what degree of certainty can we admit the existence of radical compounds in inorganic combinations?

19. What means of transport to the Indies, whether by the old route of the Cape of Good Hope or by the proposed canal across the Isthmus of Suez, may be considered the most economical for commerce—that by sailing vessels, by steamers, or by sailing vessels aided by steam?

20. The velocity with which magnetism, in whatsoever manner developed in one part of a mass of iron, diffuses itself throughout the mass is not yet ascertained. The society requests that this velocity be determined by rigorous experiments.

21. The difference of numerical results obtained by different savans as to the conducting power of different metals for electricity renders it necessary that on this point there should be a new research. The society, therefore, requests that there shall be a new determination in a rigorous manner of the relative conducting power of the metals and the alloys most in use—the former in a state of chemical purity, and the latter in exact proportions. The society desires that endeavors should at the same time be made to find the law according to which the conducting power of an alloy depends upon that of the metals of which the alloy consists.

22. The society requests a description of the fossil fauna of the Netherland provinces, Gueldre and Overijssel, compared with that of analogous formations in the adjacent countries. Should the author have satisfactory reasons for so doing, he may confine himself either to the vertebrate or to invertebrate animals of these fauna.

The ordinary prize of a satisfactory reply to either of these questions is a gold medal of the value of 150 florins, and a further gratuity of 150 Dutch florins if the reply is deemed worthy of it.

The replies, legibly written, must be made in Dutch, French, English, Italian, or Latin; or in the German language in *Roman characters;* and must be sent, *post free*, accompanied by sealed notes, in the usual manner, to M. J. G. S. Van Breda, perpetual secretary of the Holland society at Harlem.

EXTRACT FROM THE PROCEEDINGS OF THE HOLLAND SOCIETY OF SCIENCE AT HARLEM FOR THE YEAR 1861.

The society held its 109th annual session on the 18th of May, 1861.

Since its last meeting it had received—

1. A memoir, written in French, on the sponges of the seas of the Antilles.

The directors did not deem fit to come to an immediate conclusion as to the insertion of this work in the society's memoirs.

2. A memoir, written in French, by Mr. T. C. Winkler, of Harlem, containing the description of fossil fishes from the quarries at Sohlenhofen, in Bavaria.

3. A memoir presented by Dr. Bierens De Haan, *upon a method of discussing definite integrals.*

On the unanimous recommendation of the members who were consulted, the directors resolved that this memoir should be inserted in the society's transactions.

4. A memoir in reply to the following question: "Many paleontologists, and among them Von Meijer, Heer, Agassiz, and Kaup, have described and figured various animals of which remains have been found in the quarries of Oeningen, situated on the frontiers of Switzerland and of the Grand Duchy of Baden. During their researches, and subsequently, the quarries have constantly furnished new species which the society desires to see described. The society will award its gold medal to the naturalist who will present a good description, accompanied by the necessary figures, of the newly-found species, whether of mammifers, fish, or insects."

This memoir, written in German, contains the description, with a number of figures, of newly-found fossil insects from Oeningen. The society unanimously resolved to crown this memoir, and to request the author to communicate to the society whatever further information he may obtain on the subject of the fossil insects of Oeningen.

On the opening of the sealed note accompanying the memoir it was found that the author was Professor O. Heer, of Zurich.

5. A memoir, written in German, and bearing the epigraph, *Multa pertransibunt et augebitur scientia*, in reply to the following question:

"What have been the results to astronomy of the numerous discoveries of small planets revolving around the sun between the orbits of Mars and Jupiter. What is their importance, and what their promise for the future?"

This memoir is obviously from the pen of a learned and experienced astronomer. The question, however, is only answered in part, and there are serious errors in the calculations. For these reasons the society was unable to crown this memoir.

6. A memoir, written in German, and bearing the epigraph "*Die ewigen Gesetze in der Natur sind für uns die Sprache der Geisterwelt,*" in reply to the following question:

"According to most geologists, one of the latest geological periods was characterized by enormous masses of ice covering vast breadths of different countries, and forming enormous glaciers. The society inquires: 'What was the influence of these glaciers, if they really existed, upon the flora and fauna of these countries, and upon the temperature of the atmosphere?'"

The society unanimously awarded the gold medal to the author of this memoir, Professor W. Sartorius de Waltershausen, of Göttingen.

The society thinks fit to repeat the following questions, and to request replies to them *previous to the first of January,* 1863:

1. Throughout Europe the diluvial formation contains bones of the mammifers; the society asks a comparative examination of the deposits of those bones in different places leading, if not with certainty, at least with a high degree of probability, to a knowledge of the causes of their interment, and the manner in which it happened.

2. In some districts of the island of Java there are very remarkable polythalama; the society desires a description, accompanied by figures, of some species of this genus hitherto undescribed.

3. It is very probable that the chain of mountains which borders Dutch Guiana contains auriferous veins, and that the detritus at the foot of that chain contains gold. The society requires a geological description of that chain of mountains, with the result of a mineralogical examination of its detritus.

4. The society requires as complete a list as can be made of the reptiles that exist in the countries near the Dutch possession of St. George del Mina, on the coast of Guinea, with the description of new species.

5. The society requires an anatomical description of the sea-calf, (*Trichecus manatus, L.,*) which is found in the Dutch colonies in America, with an account of the habits of the animal, based on the author's observations.

6. A chemical examination is required of the phosphorescent material of *Lampyris noctiluca* and of *Lampyris splendidula, L.*

7. The celebrated astronomer G. B. Airy has expressed (vol. xix, No. 5, of Monthly Notices of the Royal Astronomical Society) some doubts regarding the manner in which it has hitherto been attempted to deduce from the apparent movements of the fixed stars the movement of the sun with the planetary system through space. Airy proposes an entirely new method of attaining the same end, a method which he has applied to only a very few stars. In view of these facts, the society requests new and exact researches upon the movement of the sun with the planetary system; these researches to be founded upon all the fixed stars whose own motion has been settled with sufficient exactness for that end.

8. Bodies in motion, when lighted by the electric spark, appear as though they were perfectly at rest; new researches are requested to be made by means of the application of this principle.

9. The society requests new researches upon the arrangement assumed by particles of iron floating upon or suspended in a liquid

under the influence of a surrounding electrical current, and an application of the phenomenon to what takes place in a bar of iron undergoing magnetization.

10. Exact experimental researches are required in order to ascertain to what extent the dispersion in transversal radii of the particles of a thread of metal by an electric discharge, described and figured by Van Marum in the Memoirs of the Teylerian Society, is analogous to the stratification of the light in rarefied gases, and ought to be attributed to the same cause.

11. Notwithstanding the experiments of Arago, uncertainty still exists as to the state of polarization of diffused light. The society requires new experimental researches, as complete as possible, as to the nature of the polarization both of diffused light and of light radiated from incandescent bodies.

12. What is the nature of the foreign bodies observable in some diamonds? Do they belong to the mineral or vegetable kingdom? Researches upon this question, even though they apply only to a single diamond, will be crowned should they lead to any interesting result.

13. As the development and first habitat of the *Bothriocephalus latus (Tœnia lata*, L.*)* are as yet unknown, the society suggests researches which shall elucidate the natural history of this entozöon from the egg to the perfect state.

14. The researches of Kramer have made it known that visual adjustment depends upon a change of form in the lenses of the eye, but the mechanism by which this change is effected is not yet well known. The society requires new researches upon this subject, to be founded on the comparative anatomy of the apparatus which serves to produce the accommodation.

15. The society requests researches into the nature of the substances contained in the watery vapor produced by the respiration of man in a state of health and of the lower animals. It is desirable that these researches should, if possible, be extended to the substances exhaled in some diseases, especially contagious ones; that they should not only be chemically analyzed, but examined as to their noxious effects upon animals.

The society has this year propounded the following questions, and requests replies before the 1st of January, 1863:

1. The fishes of the Indian archipelago have been the objects of the researches of a learned Dutch author. The society desires that the other vertebrates of these islands, and especially those of Borneo, Celebes, the Moluccas, and, above all, those of New Guinea, should be subjected to a similar examination. The gold medal will be awarded to the naturalist who shall send to the society either the description of any new species of mammifers, of birds, or of reptiles of these islands, or a memoir containing new and remarkable facts concerning the structure and habits of some of these animals.

2. The society requires a determination, as exact as possible, of the errors of Hansen's Lunar Tables, by the occultations of the

Pleiades observed during the last revolution of the node of the lunar orbit.

3. The celebrated mechanist Ruhmkorff has obtained electric sparks of extraordinary length by the induction apparatus which bear his name. The society desires a determination, by both theoretical and experimental researches, of the laws which govern the length and the intensity of the sparks from instruments of different sizes and construction.

4. What difference is there in the perception of sounds with both ears or with only one? The society desires precise researches upon this difference, and generally upon the influence of duality on the organ of hearing.

5. According to Pasteur, and other savans, fermentation is owing to the development of cryptogamia and infusoria. The society requests new and positive researches on this subject, with the addition, if practicable, of an exact description of these plants and animals, and of their mode of action.

6. What is the best construction, and what the best mode of using steamboats intending to clear rivers of the masses of ice which obstruct their water-course? The society desires that those who reply to this question will carefully consider all that practice has already determined both in this country and elsewhere.

7. The electric perturbations of the atmosphere give rise to electric currents in the telegraph wires. Notwithstanding all that recent researches have made known, these phenomena are not yet completely understood, and the society desires communications of the results of numerous observations, with an account of the most remarkable consequences which may be deduced concerning these currents and their modifications according to the different causes producing them.

8. With the exception of some sites on the eastern frontier of the kingdom of Holland, the geological formations which are covered by alluvial and diluvial deposits in this country are but very little known. The society wishes to receive an account of all that excavations in various places, and other observations, have ascertained with certainty of the nature of these formations.

9. It is known, especially from the work of Professor Roemer, of Breslau, that many of the fossils which are found near Groningen belong to the same species as those which are found in the silurian formations in the island of Gothland. This fact has led M. Roemer to conclude that the diluvium of Groningen has been transported from the island of Gothland; but that origin does not seem to be reconcilable with the direction in which the diluvium is deposited, which direction rather indicates transportation from the southern part of Norway. The society suggests a decision of this question by an exact comparison of the fossils of Groningen with the minerals and the fossils of the silurian and other formations in that part of Norway, regard being had to the modifications these minerals and fossils must necessarily have experienced from distant transportation and its consequences.

10. The combustion of steel, iron, and other metals in oxygen, is

accompanied by the appearance of a multitude of incandescent particles which leap from the surface of the body in combustion, and which, after the experiment, are found in the vessel in which the combustion is operated. The same fact is witnessed in the luminous electric arc of a strong pile between two metallic rheophores, especially if they, or even one of them, is of steel or iron. The society desires to receive an explanation founded upon new and decisive researches as to the cause of this phenomenon.

The society recalls the fact that last year it propounded the following questions, that they might be answered before the first of January, 1862:

1. The society requests new researches upon the development and the first phases of the life of the nematoides, especially of those which live in the human body.

2. As chemical affinities suffer remarkable modifications by change of temperature, and as we can now easily produce very high temperatures, the society requests a series of researches upon affinity at very high temperatures.

3. The conducting power of a metallic wire which has for some time been traversed by a galvanic current becomes diminished; this effect, if it is not constant, at least disappears but slowly. The society wishes for researches into the laws which regulate this phenomenon.

4. A description is wanted of the bony labyrinth of the organ of hearing founded on new researches, and applied to the physiology of the ear.

5. We want new experimental researches relative to the phenomenon known as fluorescence; the author will especially endeavor to ascertain what relation exists between this phenomenon and the light produced by substances which are luminous in themselves, or which become so by friction or exposure to the sun.

6. The active state of oxygen (ozone) has already been the object of the researches of many men of science; an analogous state has been believed to have been observed in many other gaseous fluids, but the observations are neither sufficiently numerous nor sufficiently exact. The society wishes to have further light thrown upon this phenomenon by new researches.

7. The researches of Spence Bate have made known the fact that some crustacea construct nests. The society requires an exact examination of that nidification among the species already known in that connexion, and, if possible, among other species. The material of which the nests are constructed, as well as the means of construction employed by the crustacea, should engage the attention of the author.

8. Many trees have their stem twisted into a spiral; a general physiological explanation is requested of this phenomenon.

9. We desire an exact examination of the volcano of the island of Amboyna, (Dutch East Indian archipelago,) which shall perfectly ascertain whether that volcano owes its origin to an upheaving of the

old strata which form the true non-volcanic formation of the island, or whether it is the production of non coherent matters cast out by the volcano and accumulated around a crater.

10. The society requests the history of the development and life of the morphological elements of the blood of vertebrated animals.

11. The tribes who people the interior of some of the great islands of the Indian archipelago are not yet sufficiently known; they are called by the name of Alfours or Horaforas. The society requests a critical review of all that travellers have reported on the subject, and a descriptive parallel alike between those tribes, in different localities, and between the Alfours and the Papuans. The value of the work would be greatly increased in the estimation of the society if it were accompanied by new observations upon the skull and other parts of the bodies of individuals belonging to these tribes.

12. The society solicits anatomico-physiological researches upon the organs of sight in the *Echinoderms*, with especial reference to the recent discoveries on the subject of these organs in the asteries.

13. The society requests exact microscopic researches upon the phenomena which accompany the disappearance of some organs, as the gills, the tail, and the crest, during the metamorphosis of the batracians. All the phenomena, especially the modification in the vessels which accompany them, should be observed, described, and carefully figured.

14. The society requests a description of the organs which have been termed the rudimentary organs in animals, and a discussion alike of the consequences deducible therefrom with respect to the natural affinities of the animals, and of what those organs allow us to presume as to the mode of the development of animal life upon the earth.

15. M. Person believes that he has found a law which connects the latent heat of the fusion of a substance with its point of fusion and with its calorific capacity in both the liquid and solid states. The society, deeming that this law is not supported by a sufficient number of facts thoroughly proved, desires that it be again subjected to a strict examination.

16. The researches of Dale and Gladstone have particularly fixed the attention of men of science upon the changes that the indices of refraction of liquids undergo by changes of temperature. The society attaches great importance to the knowledge of the relation between the indices of refraction and the temperature, from its conviction that this knowledge may tend to elucidate many other very interesting points in the theory of light. The society therefore demands a series of very exact researches upon these changes in pure liquids and solutions.

17. Physicists are not agreed upon the cause of the motion of the ball in Mr. Gore's electrical experiment. It is urged that that cause should be put beyond doubt by new and decisive experiments.

18. The researches of M. Du Moncel show that the electric light developed under certain circumstances by Ruhmkorff's apparatus con-

sists of two distinct parts—the spark, properly so called, and a luminous aureola. New researches are required upon the causes of this division, and the phenomena which accompany it, and upon the different qualities of the two parts of the same luminous discharge.

19. The experiments of M. Quincke have demonstrated that the forced passage of a liquid across a porous diaphragm developes an electric current. New researches are demanded which may make known the cause of this remarkable phenomenon.

20. The society desires soundings to be taken in various seas for the purpose of procuring specimens of the beds. The specimens thus procured are to be carefully examined with a view to discovering whatever there is that is interesting in these submarine deposits.

21. Exact researches are requested upon the transparency of the atmosphere of Java as compared with that of some European country.

22. In the mountainous country of the left bank of the Rhine, known by the name of Ejjffel, there are several conical mountains which evidently owe their existence to volcanic action. The society requests it to be determined, by exact observations made upon the spot, whether there exists traces of upheaval of the older strata, or whether those mountains are not cones of eruption.

The question relating to the fossils of Oeningen, from which the society has been so fortunate as to induce the production of crowned memoirs upon the fishes and the insects, still remains open to competitors as regards the mammifers and the reptiles.

The usual prize for a satisfactory reply to each of the questions is a gold medal of the value of 150 florins, and, when the reply is deemed worthy, an additional premium of 150 Dutch florins in money. Replies very legibly written in Dutch, French, English, Italian, or German, (in the Roman character,) and *post paid*, with sealed notes in the usual way, must be addressed to M. J. G. S. Breda, perpetual secretary of the society, Harlem.

EXTRACT FROM THE PROCEEDINGS OF THE HOLLAND SOCIETY OF SCIENCES, AT HARLEM, FOR THE YEAR 1862.

The society held its 110th annual session May 17, 1862. Since its last general session no satisfactory response has been received to the questions which it had offered for competition.

Dr. P. Bleeker, a member of the society, has sent a *Memoir intended as a contribution to the natural history of the fish of the coast of Guinea;* and Drs. F. J. S. Schmidt, G. S. Godhart, and J. Van der Hoeven have transmitted a *Memoir on the anatomy of the Cryptobranchus japonicus.* By the unanimous recommendation of the members consulted these two works will form a part of the memoirs of the society.

The society has thought proper to repeat the following questions,

and to request that reponses may be made *before the first of January*, 1864:*

1. The society requests the history of the development and life of the morphological elements of the blood of vertebrate animals.

2. The tribes which people the interior of certain large islands of the Indian archipelago, and which have been designated by the name of Alfours or Horaforas, are not yet adequately known. The society invites a critical review of all that travellers have reported on this subject, and an analytical parallel as well between the tribes belonging to different localities as between the Alfours and Papuans. The value of this work would, in the view of the society, be greatly enhanced if accompanied by new researches on the skull and other parts of the bodies of individuals pertaining to the races in question.

3. The society solicits anatomico-physiological researches on the organs of sight in the *echinoderms*, with especial reference to recent discoveries on the subject of these organs in the asteria.

4. Microscopical researches are required on the phenomena which accompany the disappearance of certain organs, such as the gills, the tail, and the crest, during the metamorphosis of batrachia. The society desires that all these phenomena, especially all the modifications in the vessels which accompany them, should be observed, described, and figured with care.

5. A description of the organs which have been denominated rudimentary organs in animals, and a discussion, as well of the consequences to be deduced from those organs in regard to the natural affinities of animals, as of the presumptions to which they lead, respecting the mode of the development of animal life on the earth.

6. M. Person believes that he has discovered a law which connects the latent heat of fusion of a substance with its point of fusion and its calorific capacity in a solid and a liquid state. The society, thinking that this law is not supported by a sufficient number of well-verified facts, desires that it should be submitted anew to a rigorous examination.

7. The researches of Dale and of Gladstone have particularly fixed the attention of physicists on the changes which the indices of the refraction of liquids undergo from changes of temperature. The society attaches great value to the knowledge of the relation between the index of refraction and the temperature, convinced as it is that this knowledge would clear up other very interesting points of the theory of light. It desires, consequently, a series of very exact researches on these changes in pure liquids and in solutions.

8. Physicists are not agreed with respect to the cause of the movement of the ball in the electrical experiment of M. Gore. It is to be wished that this cause should be placed beyond doubt by new and decisive experiments.

9. The researches of M. Du Moncel have proved that the electric light developed in certain circumstances by the apparatus of Ruhm-

* It will be seen that the following questions are given on preceding pages, but it has been thought advisable to let them stand as in the original.

korff consists of two distinct parts—the spark, properly so called, and a luminous aureole. New researches are requested as to the causes of this division, and the phenomena which accompany it, and on the different qualities of these two parts of the same luminous discharge.

10. The society desires that in the different seas specimens of the bottom should be procured by sounding; and that after examination everything of interest which these specimens disclose on the nature of the submarine deposits should be communicated.

11. We solicit exact researches in regard to the transparence of the atmosphere of the island of Java, as compared with that of some European country.

12. In the mountainous country of the left bank of the Rhine, known by the name of the Eijffel, there are several conic mountains to be seen, which evidently owe their existence to volcanic action. The society would be pleased to have it decided by exact researches made on the spot whether there exist traces of the upheaval of the older strata, or whether these mountains are only cones of eruption.

The society has this year proposed the following questions, and solicits a response to them *before the* 1*st of January*, 1864:

1. It desires a complete embryology of the *Squalus spinax* and of the *Squalus acanthias*, from the egg in the ovary to the complete formation of the young fish.

2. It calls for a critical nomenclature, based on the author's own researches, of the annulata and turbellaria, which are found in the interior and on the coasts of the Netherlands.

3. It desires a comparative myology of the anterior members of reptiles and birds, with reference to the denomination of the corresponding or homologous muscles in mammifers, and especially in the human anatomy.

4. The form of the so-called Lichtenberg figures differs according as they have been produced by positive or negative electricity. The society requests a new and satisfactory explanation of this difference.

5. Researches are desired on the molecular change produced in the filaments of different metals by the sustained action of an electric current as strong as it is possible to be without producing fusion.

6. A complete embryology of the *Lepas anatifera* is requested.

7. A comparative anatomical description is desired of the remains of birds found in different geological deposits.

8. In regard to many rocks geologists are left in doubt whether they have been deposited from a solution in water or have become solid after fusion by heat. The society desires that one of these rocks, at the choice of the inquirer, should be submitted to researches which shall lead to a decisive judgment respecting its origin, and at the same time, if possible, cast some light on the origin of other rocks more or less analogous.

9. Since at present carbonic acid may be easily solidified and without danger, it is desired that complete researches be made respecting the physical properties of the solid acid.

10. A microscopic and chemical examination is requested of the

matter secreted by glands situated near the jaws of crocodiles, which yields a strong odor of musk.

11. It is desirable to have an exact anatomical description of the sturgeon, (*Accipenser sturio*,) with a monograph of its development from the egg to the adult animal.

12. The society wishes that the remains of castors and emydes found in bogs at places where these animals do not now live should be compared with living species of these same animals.

13. Are there earthquakes which should be attributed only to the giving way of strata situated at a greater or less depth; and if so, by what signs may they be recognized?

14. It has been observed that oxygen conducts the currents of induction of Ruhmkorff's apparatus only when its tension has been reduced to the pressure of six millimetres of mercury, and that starting from this point its conducting power increases when its tension is diminished until this is but 0.5 millimetres, at which this power seems to attain its maximum. The society desires that this phenomenon should be confirmed by new experiments, and that in comparing it with whatever of an analogous kind is presented by other gases its cause should be made apparent.

The society would call to mind that it last year proposed the following questions, with a view to their being answered *before the 1st of January*, 1863:

1. Throughout Europe the diluvial contains bones of mammifers. The society asks a comparative examination of the deposit of these bones in different places, conducting, if not with certainty, at least with a high degree of probability, to a knowledge of the causes of their interment, and of the manner in which it was effected.

2. In certain formations of the island of Java are to be found highly remarkable polythalames. The society desires a description, accompanied by figures, of some species of this kind not heretofore described.

3. It is highly probable that the chain of mountains which bounds Dutch Guiana contains auriferous veins, and that the detritus at the foot of that chain contains gold. The society desires a geological description of that chain of mountains with the result of a mineralogical examination of its detritus.

4. The society desires as complete a list as possible of the reptiles which inhabit the countries in the neighborhood of the Dutch possession of St. George del Mina, on the coast of Guinea, with a description of the new species.

5. An anatomical description is desired of the sea-calf (*Trichecus manatus*, L.,) which is found in the Dutch colonies of America, with an account of the habits of the animal from observations made by the author.

6. There is desired a chemical examination of the phosphorescent matter of the *Lampyris noctiluca* and of the *Lampyris splendidula*.

7. The celebrated astronomer, G. B. Airy, has lately expressed (Monthly Notices of the Royal Astronomical Society, vol. xix, No. 5,) some doubts regarding the manner in which it has hitherto been at-

tempted to deduce from the apparent movement of the fixed stars the movement of the sun with its planetary system through space. Airy has proposed an entirely new method for attaining the same end, a method which he has applied to only a very few stars. In view of these facts, the society invites new and exact researches on the movement of the sun with the planetary system, based upon all the fixed stars whose proper movement has been determined with sufficient exactness for that purpose.

8. Bodies in motion, illuminated by the electric spark, appear as if they were in a state of perfect repose; new researches are requested to be made by means of the application of this principle.

9. The society calls for new researches on the arrangement assumed by particles of iron floating upon or suspended in a liquid, under the influence of a surrounded electrical current, and an application of this phenomenon to that which occurs in a bar of iron which is undergoing magnetization.

10. It is required to be decided by exact experimental researches up to what point the dispersion in transverse lines of a filament of metal by an electric discharge, as it has been described and figured by Van Marum in the Memoirs of the Teylerian Society, is analogous to the stratification of light in rarefied gases and ought to be attributed to the same cause.

11. Notwithstanding the experiments of Arago, there is still a prevailing uncertainty respecting the state of polarization of diffused light. The society invites new experimental researches, as complete as possible, on the nature and the state of polarization as well of diffused light as of the light radiated by incandescent bodies.

12. What is the nature of the solid bodies observed in some diamonds? Do they pertain to the mineral or to the vegetable kingdom? Researches on the subject, even if relating but to a single diamond, will be distinguished, provided they lead to any interesting result.

13. As the development and original seat of the *Bothriocephalus latus* (*Tœnia lata*, L.) are still unknown, the society suggests researches for elucidating the natural history of this entozöon from the egg to the perfect state.

14. We know by the researches of Cramer that the adjustment of the eye depends on a change in the form of the lenses, but the mechanism which produces this change is not yet well understood. The society invites new researches on this subject, based upon the comparative anatomy of the apparatus which serves to produce the adjustment.

15. The society requests researches on the nature of the substances contained in the aqueous vapor produced by the respiration as well of man in a state of health as of animals. It is desirable that these researches should, if possible, extend to the substances exhaled in certain maladies, especially contagious ones, and that not only the chemical analysis of them should be made, but that their injurious effect on animals should be examined.

16. The fishes of the Indian archipelago have furnished an object of research to one of our learned countrymen. The society is desirous

that the other vertebrata of these islands, especially those of Borneo, of Celebes, and of the Moluccas, and, above all, those of New Guinea, should be submitted to a similar examination. It will award its gold medal to the naturalist who shall send it, either the description of any new species of mammifers, of birds, or of reptiles of those islands, or a memoir containing new and remarkable facts on the structure and habits of some of those animals.

17. It is desirable to have as exact a determination as possible of the errors of the tables of the moon, which we owe to M. Hansen, by the occultations of the Pleiades, observed during the last revolution of the node of the lunar orbit.

18. The celebrated mechanist, Ruhmkorff, has obtained sparks of an extraordinary length by the apparatus of induction which bears his name. The society desires to have the laws which govern the length and intensity of these sparks in instruments of different size and construction determined by theoretical and experimental researches.

19. What difference is there between the perception of sounds with one and with two ears? The society invites precise researches on this difference, and in general on the influence of duality in the organ of hearing.

20. According to the researches of Pasteur, and other savans, fermentation is due to the development of cryptogams and of infusoria. The society desires on this subject new and positive researches, and, to such an extent as may be practicable, an exact description of these plants and animals, and of their mode of action.

21. What is the best construction and the best method of employing steamboats intended to clear rivers of the accumulations of ice which obstruct their flow of water? It is desired that in answering this question a particular account should be given of all that has been practically determined on the subject, as well in our own country as elsewhere.

22. Electric perturbations in the atmosphere give rise to electric currents in the wires of telegraphs. Notwithstanding all that modern researches have made known, these phenomena are not yet completely understood; the society desires that the results of multiplied observations should be communicated to it with an exposition of the most remarkable consequences deducible therefrom on the currents in question, and their modifications agreeably to the different causes which give rise to them.

23. With the exception of some deposits on the eastern frontier of the kingdom of the Netherlands, the geological formations covered by the deposits of alluvium and diluvium in that country are as yet but very little known. We would be gratified at receiving a statement of all which has become known with certainty, whether from the excavations executed in different places or from other means of observation, on the nature of those deposits.

24. It is known, chiefly by the labors of Professor Roemer, at Breslau, that many of the fossils found near Groningen belong to the same species with those found in the silurian deposits of the island of Gothland. This fact has led M. Roemer to the conclusion that the diluvium of Groningen has been transported from this island of

Gothland, but such origin appears little reconcileable with the direction in which this diluvium is disposed, a direction which would rather indicate a translation from the southern part of Norway. The society suggests a decision of this question by an exact comparison of the fossils of Groningen with the minerals and fossils of the silurian and other formations of that part of Norway, regard being at the same time had to the modifications to which the translation from a remote country and its consequences have subjected these minerals and fossils.

25. The combustion of steel, iron, and other metals, in oxygen, is accompanied by the appearance of a multitude of incandescent particles, which are thrown off from the surface of the body in combustion, and may be found after the phenomenon in the bottom of the vessel in which the combustion is effected. The same fact is observed in the luminous electric arch of a strong battery between two metallic rheophores, especially if these, or even one of them, is of iron or steel. The society requests an explanation founded on new and decisive researches of the cause of this phenomenon.

The usual prize for a satisfactory answer to each of these questions is a gold medal of the value of 150 florins, and a further donation of 150 Dutch florins, if the answer is thought to merit it. The answers, legibly written in Dutch, French, English, Italian, Latin, or German, (in *Italic* letters,) must be addressed free, with tickets after the manner in use, to M. J. G. S. Van Breda, perpetual secretary of the society, at Harlem.

PROGRAMME OF THE BATAVIAN SOCIETY OF EXPERIMENTAL PHILOSOPHY AT ROTTERDAM.

1. Question 105. It is desirable to obtain accurate statistical data in reference to our drained marsh districts, and this society having determined to continue its efforts, which have already been so successful in reference to South Holland, has resolved to propose the following question:

"What are the statistical characteristics of one of the drained marsh districts of our country."

The reply to this question should give an account of the situation, the figure, and the extent of this dyke district; the elevation of the surface compared with the plane of the level passing through the zero of the scale of the plane of Amsterdam; the separation of the district into dykes, dams, or other hydraulic divisions, having different summer levels; a succinct description of the windmills or other apparatus in use for pumping up and discharging the superabundant waters; such description also giving the volume of the water raised and the measure of its elevation; the indication of the changes successively made in these machines to increase their discharging power, and the effect obtained, both as to the volume of the water and as to the measure of its elevation; the description of

the canals, or water-courses, showing their lengths, their transverse section, and the obstructions which may influence the discharge of the waters. To these particulars there should be added a historical notice of the various projects for the improvement of draining; such notice to indicate the results of such projects in the cases in which they have been carried into execution. Finally, there should be a description of the means of defence against the exterior waters and the results obtained from the means employed.

2. Question 106. This society, judging that the examination of the temperature of the water of the high seas taken at considerable depths may be of much importance in conducing to a knowledge of the physical state of our globe, and knowing that on board of many vessels, under favorable circumstances, this temperature can be ascertained, solicits careful research upon this point; such research, with proper apparatus and appliances, to be made in latitudes and longitudes in which it has hitherto not been undertaken; and this society further solicits succinct and formal yet fully detailed reports of such researches.

3. Question 111. It is undeniable that the crystalline form is one of the essential properties of matter, but in the present state of our knowledge we possess only an imperfect idea of the relation which truly exists between the crystalline form of a body and its chemical composition.

Crystallographic examination, properly so-called, has hitherto been for the most part limited to objects presented to us by nature in the form of minerals, while we have only a superficial acquaintance with what we may know about crystals artificially obtained from chemical compositions or simple bodies.

The results obtained from the crystallographic examination of minerals cannot develop generally admissible natural laws, because we are very imperfectly acquainted with the conditions under which they are formed and the medium from which they are produced.

As in the artificial formation of crystals we are in every respect better able to ascertain the conditions and the medium, it is proposed that—

"A crystallographic and rigorously conducted examination be made of such inorganic substances as assume the crystalline form sufficiently to allow of cleavage:

"An inquiry be made into the circumstances under which the crystalline form of the selected substances has been modified; and this not only as to the secondary, but also as to the primary or type form."

"A critical review be made of the crystallographic description of different authors of inorganic substances, with respect to both the primary and the secondary forms."

"That the progress be stated which has been made towards obtaining a knowledge of the connexion between the crystalline form of a substance and its chemical composition. What obstacle exists to our obtaining this knowledge by the way of experiment?"

4. Question 112. A difference of opinion still existing as to what machine now in use is the best adapted for raising water, we inquire—

a. Is any one of those machines to be preferred under all circumstances and without reference to the description of the motive power?

b. In the negative case, what are the conditions which should entitle any one of those machines to the preference?

c. What, in order to obtain the best results, should be the dimensions of the hydraulic machines adapted to use in our ordinary large draining works?

The reply should be based upon exact observations and experiments, and must in every case be corroborated in the most convincing manner.

5. Question 114. During many years the learned and scientific have discussed the question of the possibility of building enclosed seaports, similar to those of northern and southern Holland, and intended for the safe sheltering of vessels of considerable draught of water. Some of those who have discussed the question maintain that in the present state of practical science there is no difficulty in the formation of such harbors. We therefore ask for a complete plan of a coast harbor, similar, for instance, to that of Scheveningue, which at low water shall admit vessels drawing twenty-one feet, and with an entrance of sufficient breadth to allow such vessels an easy entrance with wind blowing hard from the northwest. To such plan there should be added an estimate of the cost of the construction as well as of the annual repairs.

6. Question 116. The rheumameters of Brunings, Woltman, Pitot, and others, have this disadvantage: that while they indicate the relative value of velocities they do not indicate their absolute value; and the rheumameter of Kraijenhoff is adapted to the examination of only some portions of rivers. We therefore require an instrument calculated for ascertaining the mean velocity in any part of a river, and free from all the known defects of existing inventions, or having such defects remedied as far as possible.

7. Question 117. The history of the changes which have taken place in the course of rivers and in their mouths, as well as of the events which have been the causes or the results of these changes, is of the utmost consequence to obtaining a knowledge of the existing state of our rivers. Many things worthy to be known on this subject are scattered through individual dissertations, and in the debates, reports, resolutions, and memoirs of various learned and scientific societies. It would be useful to collect these things and make them known to the persons interested. Therefore, we suggest: "A judicious historical memoir on the rivers of Holland from the inundation of the Zindhollandsche Waard to the present time."

8. Question 118. Other countries already possess locks of extraordinary dimensions, and the necessity may arise for building similar locks in this country. We therefore solicit: "A critical description of the

manner in which other countries construct locks of extraordinary dimension; and which of those modes of construction deserves preference? Or, are there other modes of construction imaginable and practicable for the construction of similar locks in this country?"

9. Question 120. As the most recent observations of Dr. H. Schacht upon the origin of the lacteal vessels of the *Carica papaya** confirmed his previous experiments, published in the Botanic Journal of Von Mohl and Schlechtendal in 1851, as well as in his treatise on the Anatomy and Physiology of Vegetables, and, as they contradict the well-known observations of an anonymous writer in the same Botanic Journal in 1846, this society desires new observations with a view to putting an end, if possible, to all doubts that still exist as to the origin of the organs in question. The society, therefore, proposes the following question: "How do the lacteal vessels originate in the vegetable kingdom? In the intercellular canals of the cells, or in what other manner? And are those organs, as Dr. Schacht maintains, identical with ramified cortical fibres?"

The society requires the observations to be extended over different natural families of the vegetable kingdom; that they be illustrated by drawings, and, if possible, by microscopic preparations.

10. Question 121. During the last few years many plants have been attacked by various diseases to such an extent that the crops have been deficient, or a total failure, and that the plants themselves have languished and died.

This phenomenon deserves the attention of naturalists and of rural economists, alike with reference to science and to practice.

It is not to be wondered at, therefore, that this subject has occupied the attention of many naturalists. But as hitherto their essays have not produced any satisfactory results, as their views and explanations are constantly contradictory, and finally, as the number of the species and varieties of plants which suffer from disease seems to increase, the necessity for such researches is the more obvious and urgent.

This society, therefore, asks the following question:

"Will scientific men make an anatomico-physiological examination of the diseases of one of the most important of the cultivated plants, accompanied by a critical review of the principal theories concerning the diseases, and also by an indication of the means of preventing or counteracting them?"

The society desires at the same time that, as far as possible, microscopic preparations and drawings be made to illustrate the results of the examination.

11. Question 122. Have some portions of the sun's surface a higher degree of temperature than others; and if so, do the same portions always possess that higher temperature?

12. Question 123. "Light, heat, electricity, and magnetism, those manifestations of force which formerly were attributed to imponder-

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* *Annales des Sciences Naturelles*, 4th series, vol. 8, page 164.

able fluids, have in later times been referred to the movements of a perfectly elastic ether, penetrating all things. According to some savans, we must abandon this latter opinion also, and attribute these manifestations of force to movements of matter itself. How is this?"

The solution of this question, or at least evidence conducing to that solution, is required.

13. Question 124. "Can heat directly produce magnetic phenomena?"

This question is to be decided by experiment.

14. Question 125. The society desires to have, as applying to different primary chemical compounds, an experimental determination of the temperature at which each of them becomes decomposed, and how this temperature is modified by the presence of other substances, and under other circumstances.

15. Question 126. The influence which pressure exerts upon fluids through which a galvanic current is passing is still but little known. It has not yet been sufficiently determined whether the decomposition may be entirely stopped by pressure upon the electrolyte; for instance, by completely confining the latter in a strong vessel in which the electrolysis would, in ordinary circumstances, produce gases. It seems that an examination to this effect would be of some importance, both as to voltametric operations and as to the valuation of the work done by the galvanic current. The question, then, is: "What influence has pressure upon decomposition, and how far in this is there a confirmation of the conservation of force?"

This examination should extend to at least three liquids, to be selected at the pleasure of the examiner himself.

16. Question 127. A mathematical theory is required of the aneroid barometer of Vidi, as well as of Bourdon's metallic barometer; such theory not overlooking the influence of temperature.—(See Lamé's Theory of Elasticity.)

17. Question 128. A geological description of the Island of Banda.

18. Question 129. We require a decision of this question: "When steam boilers burst (other causes being left out of view) are we to to suspect a development of hydrogen gas, or a transition of the water into the spheroidal state?"

This examination must be confirmed by a collection of exact and authentic reports of cases of bursting of boilers, and, if possible, by experiments expressly made to this end.

19. Question 130. An exposition is requested of the anatomical and microchemical composition, and also of the biography, of one or more species of a family of plants indigenous to the Netherlands, or to some one of their colonies, and previously not satisfactorily examined.

The reply to this question must be accompanied by the necessary figures upon a scale calculated to give a clear idea of the object.

CONDITIONS OF THE COMPETITION.

The gold medal of the society, of the weight of thirty ducats, or its money value, at the option of the author, will be awarded to him whose answer to any one of the above questions shall be adjudged to be the best; while an extra premium of at least fifty, and at most one hundred and fifty florins, will be given to the author of the paper receiving the golden prize, if it be pronounced eminently meritorious.

For the reply next in merit to that which takes the golden prize a silver medal will be given if such reply have peculiar merit.

The replies to the questions must be made in German, Dutch, Latin, French, or English, and must be distinctly and legibly written, inclusive of all alterations and additions, in some other hand than that of the author; they must not be signed with the name of the author, but marked with some sentence or motto which, together with the name and address of the author, shall be repeated in a sealed note accompanying the manuscript, which must be sent, post free, on or before the 1st of February, 1863, to the director and chief secretary, Dr. D. F. Van der Pant.

The notes accompanying the replies which obtain the gold medals will be immediately opened in the general assembly, and those accompanying the replies which do not obtain prizes will be in the same assembly burned unopened; the notes accompanying the replies which obtain the silver medal will not be opened until after the authors make themselves known, and those, the authors of which shall not make themselves known in the interval of time fixed in the programme, will be burned unopened in the first general assembly.

The society reserves the right of inserting in its transactions the crowned replies, either in whole or in part, or altogether to abstain from such insertion; and previous to the publication of the society's transactions the authors of the prize answers will not be at liberty to have them printed or otherwise to make public use of them without permission of the directors.

We may here repeat our former announcement that the society will, with pleasure, receive and examine all treatises and memoirs concerning experimental philosophy and its applications, with a view to publishing them in its transactions, if suitable for that purpose, provided that every such paper bear the signature of the author, or be accompanied by a sealed note containing such signature. And further, the society will award the gold or silver medal to the most important of such papers as shall be delivered on or before the 1st of February, 1863.

QUESTIONS SUBMITTED TO COMPETITION BY THE SOCIETY OF ARTS AND SCIENCES ESTABLISHED AT UTRECHT.

The questions proposed by the society, in reference to subjects purely local, are not comprised in this programme.

1. A series of researches into the warmth generated by plants.

2. What is the state of our knowledge as regards the manner and degree in which the air is vitiated by the respiration and perspiration of men; and what are the means to be adopted for purifying the atmosphere in dwelling-houses and in buildings destined for large assemblies.

3. The society requires investigations into the course of the filaments of the nerves in the spinal cord, commencing at the roots of the nerves in one or more animals. The competitors must not only make use of the microscope, in combination with the mode of investigation adopted by Waller, but also of physiological experiments.

4. A dissertation on the life and merits of Christiaan Huyghens is requested.

5. Required an essay upon the affinity of the Greek and Sanscrit languages, containing a critical and systematic exposition of the results of the linguistic investigations on this subject, and stating clearly how far a comparative study of these two languages has promoted or may yet promote the profound knowledge of the first of them.

6. A dissertation on Justinian and his age.

7. An historical and critical investigation of the various modes in which the system of Hegel has been developed since his death, in 1831, and what has been its influence upon other branches of knowledge, in particular on the doctrine regarding God and the world. The relation of that development and influence to other theories and systems of later times should also be indicated.

8. An historico-critical review of the Malayan literature. Not only an examination of the published, but as much as possible also of unpublished Malayan works is required.

9. A history of the settlement of the Dutch in Guinea, or on the west coast of Africa, from the beginning of that settlement to our own day.

10. Historia critica tribunatus Plebis, quæ interiorem civitatis Romanæ conditionem per varia deinceps tempora spectandam præbeat.

11. Exploretur et diiudicetur Asinii Pollionis de C. Julii Cæsaris commentariis sententia, quæ exstat in Suetonii Cæsare c. 56: "eos Pollio Asinius parum diligenter parumque integra veritate compositos putat: quum Cæsar pleraque, et quæ per alios erant gesta, temere crediderit; et quæ per se, vel consulto, vel etiam memoria lapsus, perperam ediderit."

12. Disquisitio de loco difficiliore vel controverso ad disciplinam antiquitatis sive græcæ seu latinæ pertinente.

13. Eruantur ex Inscriptionibus Latinis, quæ in variis Romani imperii regionibus sunt repertæ, et e Grammaticorum veterum indiciis eæ voces et formæ, in quibus proprii regionis cuiusque sermonis vestigia agnoscantur, eæque accurate collectæ ita disponantur, ut quæ et

qualia fuerint Latini sermonis idiomata in variis imperii Romani partibus usurpata, quantum fieri possit, efficere inde liceat.

14. Disquisitio de T. Livii dictione, qua proprietas eius in verborum usu et constructione, exemplis diligenter collectis ordineque dispositis et illustratis, exponatur, et quatenus in ea ἰδιωτισμου, quem *Patavinitatis* nomine ei obiecit Asinius Pollio, vestigia exstare videantur, ostendatur.

A gold medal of the value of 30 ducats (13 pounds sterling,) or an equivalent in silver, will be accorded to the successful competitor. This prize will be doubled for questions Nos. 2 and 13. The answers must be sent in (post free) previous to the 30th of November 1861—those to the 13th only, before the 30th of November, 1863, addressed to Dr. J. W. Gunning, the secretary of the society, at Utrecht. The author is at liberty to write in the English, Dutch, German (in Italic characters,) French, or Latin language; but in answering to questions 10, 11, 12, 13, and 14, the Latin language is required. The answers must not be in the author's own handwriting; they are to be accompanied by a sealed envelope, enclosing his name, and if a member of the society, having the letter "L" on the address. The successful answers will be published in the society's works.

Further information may be obtained on application to the secretary of the society.

EXTRACT FROM THE PROCEEDINGS OF THE ROYAL ACADEMY OF THE NETHERLANDS.

The senate of the Royal Academy for the Promotion of Letters, Philosophy, and History, received, pursuant to the bequest and testament of Hœufftian, during the past year eight poems from five poets. The first is entitled "On the Divine Excellency of Learning;" the second, "Ode addressed to Bartholomew Burghesium on the Death of John Marchetti;" the third, "On the Decay of the Gallic Language;" the fourth, fifth, and sixth, bear the title in common, "On Italian Affairs during the years 1848 and 1849; Three Unpublished Odes;" the separate titles of which are: *a.* "The Assault of Peschiera and the Victoria Goidensis, addressed to King Charles Albert;" *b.* "Griefs of Mourning Italy;" *c.* "Fortunes and Death of King Charles Albert in Exile;" the seventh is, "The Tauric Peace, a Mythological Poem, addressed to Poets;" and the eighth, "The Hero Garibaldi."

Upon these poems the academy, in its session on the 8th day of April, pronounced the following judgment:

The first is weak and dubious in its argument, wanting in poetical coloring and spirit, and expressed in language very far from being either pure or perspicuous. The second is unacceptable, for two reasons: first, it consists of fewer than the fifty verses which are expressly demanded; and secondly, because it has already appeared in print. The third, besides having all the faults of the first, some-

times violates the fundamental laws of metre. The three odes, which answer to the fourth, fifth, and sixth poems, so progressively descend in the scale of elegant Latinity, perspicuity, and true poetic fervor, that the second ode is more faulty than the first, and the third than either. The seventh poem is throughout couched in language less fitted to poetry than to prose, and even that not terse or good Latin, and, in brief, has scarcely one redeeming merit. Finally, the eighth poem is in the form, by no means commendable, of an acrostic; and moreover, the author is so thoroughly unskilled in the elements of metre, so completely a novice in the Latin language, that he cannot even be fairly called a versifier.

The academy, therefore, has decided that the prize can be awarded to none of these poems, and that all the sealed notes containing the names of the authors be burnt.

The academy again invites competition on the part of foreigners as well as residents for the Hœufftian prize for the best Latin poem.

The prize to be contended for is a gold medal of the value of 120 florins, and will be awarded to the author of that Latin poem, if not fewer than fifty verses, not translated from any other language, and never published, which the judges appointed by the academy shall pronounce to be worthy of the honor.

Poems intended for this competition must be sent in prior to the first of January, 1862, to H. J. Koenen, unsigned by the authors, but accompanied by sealed notes containing their names.

The result of the competition will be pronounced in public session of the academy, to be held before the month of April, 1862.

The poem to which the judges award the prize will be printed at the charge of the Hœufftian bequest. The sealed notes of the unsuccessful competitors will be burned, and the poems returned to the authors who claim them.

I. DeWal,
President of the Academical Senate.

CONTENTS.

REPORT OF THE SECRETARY.

GENERAL APPENDIX.

INDEX.